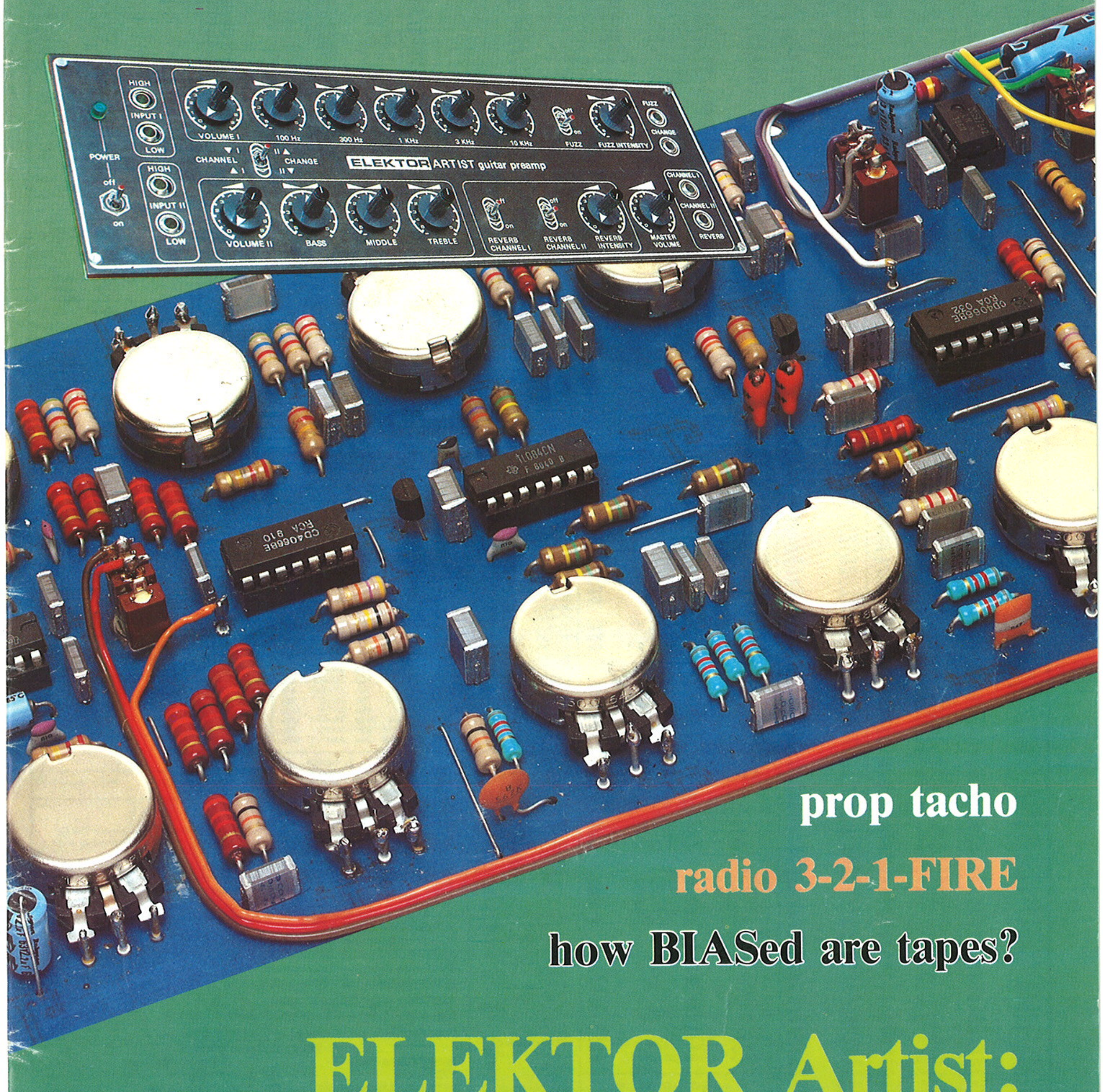
D 71683

elektor

85
May 1982
65p.
IR 85p. (incl.VAT)
CAN $ 2,25

up-to-date electronics for lab and leisure



prop tacho

radio 3-2-1-FIRE

how BIASed are tapes?

ELEKTOR Artist: the ultimate guitar preamp

Z-80 CPU Card

6502 housekeeper

TTLs

7400	11p
7401	12p
7402	12p
7403	12p
7404	12p
7405	18p
7406	25p
7407	25p
7408	14p
7409	16p
7410	15p
7411	20p
7412	20p
7413	22p
7414	35p
7416	25p
7417	25p
7420	17p
7421	20p
7422	20p
7423	22p
7425	28p
7426	30p
7427	25p
7428	30p
7430	15p
7432	25p
7433	27p
7437	27p
7438	30p
7440	17p
7441	70p
7442A	36p
7443	90p
7444	112p
7445	60p
7446A	93p
7447A	45p
7448	45p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	30p
7474	20p
7475	38p
7476	30p
7480	50p
7481	100p
7482	70p
7483A	50p
7484	100p
7485	90p
7486	20p
7489	210p
7490A	25p
7491	60p
7492A	30p
7493A	30p
7494	50p
7495A	50p
7496	45p
7497	120p
74100	85p
74104	65p
74105	65p
74107	22p
74109	40p
74110	55p
74111	70p
74116	90p
74118	75p
74119	90p
74120	70p
74121	28p
74122	45p
74123	48p
74125	40p
74126	40p
74128	40p
74132	45p
74136	32p
74141	65p
74142	200p
74145	70p
74147	100p
74148	75p
74150	80p
74151A	45p
74153	45p
74154	70p
74155	50p
74156	50p
74157	50p
74159	100p
74160	60p
74161	60p
74162	60p
74163	60p
74164	50p
74165	55p
74166	70p
74167	200p
74170	160p
74172	300p
74173	75p
74174	70p
74175	70p
74176	50p
74177	70p
74178	100p
74180	60p
74181	160p
74182	90p
74184A	90p
74185	120p
74186	500p
74188	325p
74190	70p
74191	70p
74192	70p
74193	70p
74194	70p
74195	60p
74196	60p
74197	60p
74198	100p
74199	100p
74221	75p
74251	70p
74259	120p
74278	150p
74279	80p
74283	75p
74284	200p
74285	200p
74290	100p
74293	100p
74298	100p
74365	55p
74366	55p
74367	55p
74368	55p
74390	100p
74393	100p
74490	120p

74LS SERIES

74LS00	12p
74LS02	12p
74LS03	14p
74LS04	14p
74LS05	15p
74LS08	14p
74LS09	15p
74LS10	15p
74LS11	15p
74LS12	20p
74LS13	25p
74LS14	40p
74LS15	30p
74LS20	15p
74LS21	15p
74LS27	16p
74LS30	15p
74LS32	16p
74LS33	20p
74LS37	16p
74LS38	16p
74LS42	36p
74LS47	40p
74LS51	15p
74LS55	30p
74LS73	25p
74LS74	16p
74LS75	24p
74LS76	20p
74LS83	45p
74LS85	65p
74LS86	20p
74LS90	28p
74LS92	40p
74LS93	30p
74LS96	100p
74LS107	45p
74LS109	30p
74LS112	34p
74LS113	30p
74LS114	30p
74LS122	42p
74LS123	50p
74LS124	120p
74LS125	30p
74LS126	30p
74LS132	45p
74LS133	30p
74LS136	30p
74LS138	36p
74S138	220p
74LS139	36p
74LS145	75p
74LS147	160p
74LS148	90p
74LS151	70p
74LS153	60p
74LS154	90p
74LS155	40p
74LS156	40p
74LS157	35p
74LS158	36p
74LS160	40p
74LS161	40p
74LS162	40p
74LS163	40p
74LS164	48p
74LS165	100p
74LS166	90p
74LS170	120p
74LS173	70p
74LS174	45p
74LS175	50p
74LS181	140p
74LS190	50p
74LS191	50p
74LS192	50p
74LS193	48p
74LS194	40p
74LS195	48p
74LS196	60p
74LS197	65p
74LS221	60p
74LS240	70p
74LS241	70p
74S241	400p
74LS242	80p
74LS243	80p
74LS244	65p
74LS245	65p
74LS247	70p
74LS248	90p
74LS249	90p
74LS251	50p
74LS253	40p
74LS257	45p
74LS258	45p
74LS259	90p
74LS266	25p
74LS273	75p
74LS279	45p
74LS283	45p
74LS298	160p
74LS299	400p
74LS323	250p
74LS324	150p
74LS348	150p
74LS352	100p
74LS353	100p
74LS363	160p
74LS364	160p
74LS365	36p
74LS367	36p
74LS368	36p
74LS373	70p
74LS374	70p
74LS375	50p
74LS377	90p
74LS378	70p
74LS390	55p
74LS393	50p
74LS399	200p
74LS445	140p
74LS540	135p
74LS541	135p
74LS640	300p
74LS641	300p
74LS642	300p
74LS643	300p
74LS644	300p
74LS668	100p
74LS669	100p
74LS670	170p

4000 CMOS

4000	12p
4001	14p
4002	15p
4006	65p
4007	16p
4008	60p
4009	35p
4010	40p
4011	14p
4012	16p
4013	35p
4014	60p
4015	60p
4016	30p
4017	45p
4018	60p
4019	32p
4020	60p
4021	65p
4022	70p
4023	20p
4024	40p
4025	20p
4026	130p
4027	32p
4028	60p
4029	75p
4030	40p
4031	170p
4033	180p
4034	160p
4035	80p
4036	295p
4037	115p
4038	120p
4039	295p
4040	55p
4041	70p
4042	55p
4043	60p
4044	70p
4045	120p
4046	70p
4047	75p
4048	55p
4049	27p
4050	27p
4051	60p
4052	80p
4053	60p
4054	130p
4055	125p
4056	120p
4059	500p
4060	90p
4063	100p
4066	35p
4067	400p
4068	18p
4069	18p
4070	18p
4071	18p
4072	18p
4073	20p
4075	20p
4076	60p
4077	25p
4081	16p
4082	20p
4086	72p
4089	150p
4093	40p
4094	150p
4095	95p
4096	95p
4097	340p
4098	90p
4099	120p
40100	220p
40101	132p
40102	180p
40103	180p
40104	99p
40105	120p
40106	45p
40107	60p
40108	470p
40109	100p
40110	300p
40114	250p
4502	70p
4503	50p
4507	40p
4508	200p
4510	65p
4511	50p
4512	65p
4514	150p
4515	150p
4516	75p
4518	45p
4520	70p
4521	150p
4526	75p
4527	90p
4528	75p
4532	90p
4534	500p
4536	300p
4538	120p
4543	100p
4553	290p
4555	50p
4556	60p
4560	180p
4566	180p
4568	300p
4569	180p
4572	30p
4583	90p
4584	45p
4585	100p
4724	150p
40014	90p
40085	90p
40097	90p
14411	700p
14412	900p
14433	1100p
14495	400p
14500	700p
14599	290p
CD22100	350p
CD22101	700p
CD22102	700p

COUNTERS

74C925	550p
74C928	600p
ICM7216B	2000p
ICM7217A	850p
MK50398N	750p
ZN1040E	700p

TTL & ECL

MC4024	325p
4044	325p
10116	70p
10231	350p

LINEAR I.Cs

AY1-0212	600p	MC1496	70p
AY1-5050	140p	MC3340P	120p
AY3-8910	700p	MC3401	
AY3-8912	650p	MC3403	90p
AY5-1224A	240p	MK50398	750p
AY5-4007D	520p	ML920	800p
CA3019	80p	MM57160	620p
CA3046	70p	NE531	150p
CA3038	225p	NE555	18p
CA3080E	72p	NE556	60p
CA3086	48p	NE564	420p
CA3089E	225p	NE565	130p
CA3090AQ	375p	NE566	155p
CA3130E	90p	NE567	140p
CA3140E	50p	NE571	425p
CA3160E	100p	NE5534A	250p
CA3161E	190p	RC4136	70p
CA3162E	450p	RC4151	200p
CA3189E	300p	S566B	260p
DAC1408-8	200p	SAA1900	£16
HA1388	270p	SAD1024A	1250p
ICL7106	850p	SFF96364	800p
ICL8038	300p	SL490	350p
LF13331	310p	SN76477	175p
LF351	48p	SP8515	750p
LF356P	95p	TA7205	200p
LM10C	425p	TAA550	50p
LM301A	27p	TAA621	275p
LM310	120p	TBA641B	300p
LM311	75p	TBA651	200p
LM318	200p	TBA800	90p
LM319	225p	TBA810	100p
LM324	45p	TBA820	90p
LM339	65p	TBA950	300p
LM348	75p	TC9109	£10
LM358P	75p	TCA210	350p
LM377	175p	TCA220	350p
LM380	75p	TCA940	200p
LM381AN	180p	TDA1004A	300p
LM386	95p	TDA1008	320p
LM387	120p	TDA1010	225p
LM389	95p	TDA1022	550p
LM393	100p	TDA1024	120p
LM394	350p	TDA1034B	250p
LM709	36p	TDA1170	300p
LM710	50p	TDA2002V	325p
LM711	70p	TDA2020	320p
LM733	100p	TDA2541	350p
LM741	18p	TLO71/81	45p
LM747	70p	TLO72/82	75p
LM748	35p	TLO74	130p
LM1886	700p	TLO84	110p
LM1889	350p	TLO94	200p
LM2917	200p	TL170	50p
LM3900	55p	UAA170	170p
LM3909	95p	ULN2003	100p
LM3911	130p	XR2206	300p
LM3914	210p	ZN414	90p
LM3915	225p	ZN419C	225p
LM3916	225p	ZN424E	135p
LM13600	125p	ZN425E8	350p
MB3712	200p	ZN426E	350p
MC1310P	150p	ZN427E8	625p
MC1458	40p	ZN1034E	200p
MC1495L	350p	ZN1040E	700p

CPU's

1802C	700p
2650A	1200p
6502	450p
6800	370p
6802	425p
6809	£10
INS8060	1100p
8080A	350p
8085A	550p
8088	£19
Z80	370p
Z80A	450p
Z80B	£16

SUPPORT DEVICES

3242	800p
6522	500p
6532	775p
6551	650p
6821	160p
6850	160p
6852	250p
8205	220p
8212	160p
8216	160p
8224	250p
8228	250p
8251	350p
8253	800p
8255	350p
8257	800p
8259	800p
8279	950p
Z80P10	350p
Z80AP10	400p
Z80CTC	350p
Z80S10I	£20

MEMORIES

2101-4L	400p
2102-2L	120p
2107B	500p
2111-4L	400p
2112	300p
2114L	100p
2114L-2	120p
4027	375p
4116L-2	75p
4118	400p
4164	650p
4816AP-3	£5
5101L	350p
6116P-3	650p
6116LP-3	£10
6514	300p
6810	200p

PROMS

71301	700p
74S188	275p
74S201	350p
74S287	350p
74S387	350p
74S470	600p
74S471	600p
74S571	650p
74S573	900p
82S123	300p
82S137	750p
93427	400p
93436	650p
93446	650p
93448	900p

BAUD RATE GENERATOR

COM8116	£8
MC14411	£7

EPROMS

1702A	600p
2516	250p
2708	400p
2716	250p
2532	600p
2732	550p
2716 300nS	500p
2732 300nS	750p

UARTS

AY-3-1015D	300p
AY-5-1013A	300p
IM6402	450p
TR1602	300p
COM 8017	800p

CHARACTER GEN.

RO-3-2513U.C.	700p
RO-3-2513L.C.	700p
74S262N	500p

CRT CONTROLLER

COM 5037	£18
MC6845	£10
MC6847	£10
SFF96364	£8
9365	£60
TMS9927	£18

KEYBOARD ENCODER

AY-5-2376	700p
74C 922N	500p

CRYSTALS

100KHz	300p
200KHz	300p
1MHz	300p
1.008MHz	370p
1.843MHz	250p
2.0MHz	250p
2.457MHz	250p
3.276MHz	150p
3.57945MHz	100p
4.0MHz	150p
4.19MHz	200p
4.43MHz	150p
6.0MHz	150p
7.0MHz	150p
8.0MHz	175p
8.867MHz	175p
10.7MHz	150p
15.0MHz	350p
18MHz	200p
26.690MHz	210p
27.145MHz	210p

MODULATORS

6MHz UHF	350p
8MHz UHF	450p

TELETEXT DECODER

SAA5020	£6
SAA5030	£9
SAA5041	£16
SAA5050	£9

INTERFACE ICS

AD558	775p
AD561J	1400p
DM8123	175p
DM8131	375p
DP8304	450p
DS8835	250p
DS8836	150p
DS8838	225p
MC1488	55p
MC1489	55p
MC3446	325p
25S10	350p
3242	800p
3245	450p
58174	1200p
75107	160p
75110	160p
75150	140p
75154	160p
75182	230p
75324	250p
75361	150p
75363	300p
75365	150p
75451/2	72p
75491/2	72p
8T26	120p
8T28	140p
8T95	140p
8T97	140p
81LS95	90p
81LS96	90p
81LS97	90p
81LS98	90p
9601	110p
9602	220p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TEXAS

8 pin	30p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

JUMPER LEADS

24'' Ribbon cable with DIP Headers

	14 pin	16 pin	24 pin	40 pin
Single End	145p	165p	240p	380p
Double End	210p	230p	345p	540p

24'' Ribbon cable with sockets

	20 pin	26 pin	34 pin	40 pin
Single End	160p	210p	270p	340p
Double End	290p	385p	490p	540p

24'' Ribbon cable with edge conn.

	20 way	34 way	40 way	50 way
Single End	275p	525p	600p	650p

24'' Cable with 25 way D Connector
Male **500p** Female **540p**

IDC CONNECTORS

	10 way	20 way	26 way	34 way	40 way
Header Plug	90p	150p	200p	240p	270p
Receptacle	90p	165p	200p	240p	270p
Edge Conn.	200p	250p	320p	380p	560p

EURO CONNECTORS

		Plug	Socket
DIN 41612	2 × 32-way	300p	350p
angled	2 × 32-way	350p	400p
angled	3 × 32-way	400p	—
(for 2 × 32 way specify a + b or a + c)			
DIN 41617	31-way	200p	200p

MIN. D CONNECTORS

	9 way	15 way	25 way	37 way
MALE				
solder	95p	135p	200p	280p
angled	160p	230p	265p	425p
FEMALE				
solder	125p	190p	245p	375p
angled	175p	240p	310p	500p
hood (top/side entry)	100p	100p	100p	150p

37 way Centronix Type conn. **£6.50**

COUNTERS

VOLTAGE REGULATORS
Fixed Plastic TO-220

1A	+ve		−ve	
5v	7805	50p	7905	55p
6v	7806	50p	7906	70p
8v	7808	55p	7908	70p
12v	7812	50p	7912	55p
15v	7815	55p	7915	60p
18v	7818	55p	7918	60p
24v	7824	55p	7924	60p

100mA +ve		TO-92		
5v	78L05	30p	79L05	60p
12v	78L12	30p	79L12	60p
15v	78L15	30p	79L15	60p

OTHER REGULATORS

LM309K	140p		
LM317T	200p	78MGT2C	140p
LM323K	500p	79GUIC	225p
LM723	37p	79HGKC	650p
78GUIC	200p	78PO5	900p
78HO5	550p	RC4195NB	150p
78HGKC	600p	TL497	300p

TRANSISTORS

BC107/8	11p	BC557B	16p	MJ2955	90p	2N2646	45p
BC109/C	12p.	BC558B	12p	MJ3001	225p	2N2905A	30p
BC140	40p	BC559C	18p	MJE2955	130p	2N3053	30p
BC141	40p	BCY70	18p	MJE3055	100p	2N3054	65p
BC160	40p	BCY71/2	22p	MPF102	40p	2N3055	50p
BC161	40p	BD131/2	50p	MPF103/4	35p	2N3442	140p
BC177	18p	BD135/6	50p	MPF105	35p	2N3702/3	12p
BC178/9	20p	BD139	50p	MPSA12	50p	2N3704/5	12p
BC182/L	9p	BD140	50p	TIP29A/C	45p	2N3773	300p
BC183/L	9p	BD241B	70p	TIP30A/C	50p	2N3819	22p
BC184/L	9p	BD242B	70p	TIP31A/C	60p	2N3820	40p
BC212/L	9p	BF244B	40p	TIP32A/C	75p	2N3866	100p
BC213/L	9p	BF256B	70p	TIP35C	290p	2N3904/6	18p
BC214/L	9p	BF257/8	36p	TIP36C	340p	2N4871	60p
BC327	16p	BF259	40p	TIP41A/C	72p	2N5245	40p
BC337	16p	BF337	30p	TIP42A/C	80p	2N5457/8	40p
BC338	16p	BFR96	180p	TIP2955	90p	2N5459	40p
BC477	30p	BFT66	200p	TIP3055	70p	2N6027	48p
BC516/7	40p	BFY50/1	30p	2N918	45p	3N128	120p
BC547B	16p	BFY52	30p	2N2160	350p	3N140/1	120p
BC548B	12p	BFY90	90p	2N2219A	30p	40673	75p
BC549C	18p	MJ2501	225p	2N2222A	30p	40871/2	100p

KEYBOARD SWITCHES

Sq. Switch	50p
Digitast	75p
Mini Digitast	75p
Specify Colour	

EXPERIMENTOR BREADBOARDS

Exp 300	£5.75
Exp 325	£3.25
Exp 350	£3.15
Exp 600	£5.25

VALVO HUMIDITY SENSOR	**£6.00**
BL 30 HR COIL	**£1.50**
MINI ORGAN IC SAA1900	**£16.00**

VERO BOARD
(COPPER CLAD)

2.5'' × 5''	90p
2.5'' × 3.75''	80p

MICRO BOARD

Single Eurocard	£3.80
Double Eurocard	£5.25

Vero Wiring Pen	£3.40
Wire Wrapping Tool	£4.70
Veropins (100/pkt)	50p
Spot face cutter	£1.30
Pin Insertion Tool	£1.80

LOGIC PROBE KIT **£12**

ELEKTERMINAL KIT **£50** + **70p** p & p

SOFTY II

Software/Hardware development tool for programming, de-bugging/verifying and burning most +5v EPROMS.
Complete with PSU **£169** + **£2** p & p

UV Eraser with built-in safety features
UVIB **£42** + **£1** p & p

OPTO-ELECTRONICS

2N5777	40p	ORP60	120p
OCP71	250p	ORP61	120p
ORP12	90p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MSC2400	190p	TIL116	90p

LEDS

0.125''		0.2''	
TIL32	55p	TIL220 Red	12p
TIL209 Red	11p	TIL222 Gr	18p
TIL212 Ye	25p	TIL228 Ye	22p
TIL211 Gr	20p	Rectangular	
TIL216 Red	18p	LEDS (R, G, Y)	30p

DISPLAYS

3015F	200p		
DL 704	140p	NSB5881	570p
DL 707 Red	140p	TIL311	600p
DL 707 Gr	140p	TIL312/3	110p
DL 747 Red	225p	TIL321/2	130p
DL 747 Gr	225p	TIL330	140p
FND357	120p	7750/60	200p
FND500	120p	**DRIVERS**	
FND507	120p	9368	250p
MAN3640	175p	9370	300p
MAN4640	200p	UDN6118	320p
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contents

selektor 5-12

test tone generator 5-14
How 'BIASed' are tapes? Although noise reduction and equalisation are necessary, the factor which contributes a considerable amount to the quality of recordings is correct application of 'bias'. In order to set this and match tape to recorder, a test tone generator as described in this article is required.

the digital keyboard assembly and debounce circuitry for the Polyformant 5-17
U. Götz and R. Mester
As promised in the March issue, readers can commence building the Polyformant. The article is devoted to the practical side, starting with the debounce circuits for the keyboard contacts and the input unit.

miniature MW receiver 5-24
Using a well-proven chip, the article introduces a circuit with very few components, outperforming many commercially produced sets! In short a matchbox radio to set the world on fire.

the Junior Computer as a frequency counter 5-26
G. Sullivan
Microprocessors are often regarded as mathematical wizards. So why not use their aptitude for maths to the full and employ them also as a frequency counter?

Z80-A-CPU card 5-28
U. Götz and R. Mester
The Z80 is one of the most popular microprocessors around. It's about time the device was mentioned in Elektor. Although the Z80-A-CPU is the heart of the control unit for the new Polyformant, it is compatible with the Elektor bus system, therefore making the Eurocard collection accessible to Z80 users.

the Elektor Artist 5-32
It could be described as the ultimate in versatility for the electric guitar. This preamplifier (which can be used with any electronic instrument), provides a total of four inputs into two channels; extensive tone controls; built-in reverb and fuzz, with a large number of 'loop' switching facilities, giving the musician something at a reasonable cost which can only be found on more expensive equipment. We feel sure the Artist will satisfy constructors and discerning musicians alike.

prop. tachometer 5-39
A rev-counter for model aeroplanes. This design bridges the gap between the differing worlds of electronics and balsa wood. When matching a particular propeller to an engine a reliable method for measuring the rpm is extremely useful. The circuit described is straightforward in construction.

6502 housekeeper 5-42
Not just a clock but a sophisticated housekeeper based on the 6502 microprocessor. It can be used to control a multitude of household appliances, such as cookers, lighting, alarms, central heating. Set it weeks in advance and go on holiday without a care in the world.

RAM/EPROM card for the Z80 5-51
A. Seul
In principle the RAM/EPROM card (Elektor September 80) can be used with a variety of systems. Just a 'cut and shunt' exercise with no additional components is required to interface this card to the Z80 and more importantly to the Z80-A-CPU, as introduced elsewhere in this issue.

software cruncher and puncher 5-54
An unusual title perhaps, but one which succeeds in describing in as few words as possible what this article is about: a disassembler and EPROM programmer for the Junior Computer.

market 5-57

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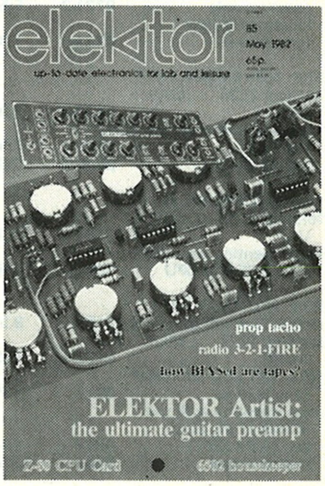

epsservice

Many Elektor circuits are accompanied by designs for printed circuits. For those who do not feel inclined to etch their own printed circuit boards, for their own use only, a number of these designs are available as ready etched and pre-drilled boards. Delivery time is approximately three weeks, U.K./air mail.

Example:
digisplay (E13) 9376 3.25 7.25
1 2 3 4 5

1. **Circuit title**
2. **reference to associated article(s)**
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		£	$
E26: JUNE 1977			
formant: keyboard interface (E25)	9721-1	3.35	8.—
E29: SEPTEMBER 1977			
formant (E25, E26):			
interface receiver	9721-2	1.40	3.50
power supply	9721-3	5.50	13.—
keyboard divider (one octave)	9721-4	1.30	3.—
E31: NOVEMBER 1977			
formant (E25 . . . E30):			
VCO	9723-1	9.90	23.50
experimenting with the SC/MP:			
RAM-I/O	9846-1	6.90	16.50
SC/MP board	9846-2	2.60	6.—
E32: DECEMBER 1977			
formant (E25 . . . E31):			
VCF	9724-1	4.35	10.50
experimenting with the SC/MP (E31): CPU	9851a	12.90	31.—
E33: JANUARY 1978			
simple function generator	9453	3.25	8.—
formant (E25 . . . E32):			
ADSR	9725-1	4.20	10.—
UAA 180 LED voltmeter (two boards)	9817	2.70	6.50
experimenting with the SC/MP (E31, E32):			
bus board (E57)	9857	4.—	9.50
memory card	9863	12.60	30.—
E34: FEBRUARY 1978			
formant (E25 . . . E33):			
DUAL-VCA	9726-1	4.35	10.50
experimenting with the SC/MP (E31 . . . E33):			
HEX-I/O	9893	18.20	43.50
E35: MARCH 1978			
formant (E25 . . . E34):			
LFO module	9727-1	4.50	11.—
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E36: APRIL 1978			
formant (E25 . . . E35):			
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E38: JUNE 1978			
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E39/40: SUMMER CIRCUITS 1978			
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E41: SEPTEMBER 1978			
formant			
24 dB VCF	9953-1	4.10	10.—
E42: OCTOBER 1978			
resonance filter module	9951	4.45	10.50
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E43: NOVEMBER 1978			
ASCII keyboard	9965	7.70	18.50
E44: DECEMBER 1978			
elekterminal	9966	7.50	18.—
E48: APRIL 1979			
TV games computer:			
UHF/VHF modulator (see E42, October 1978)	9967	1.55	4.—
main board and documentation	79073	19.95	47.50
power supply	79073-1	2.45	6.—
keyboard p.c.b.	79073-2	3.65	8.50
Complete set of four boards (9967, 79073, 79073-1, 79073-2), documentation and one ESS software record (ESS 006):		26.25	62.50
E49: MAY 1979			
BASIC microcomputer	79075	6.40	15.—
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E50: JUNE 1979			
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E53: SEPTEMBER 1979			
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E55: NOVEMBER 1979			
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E56: DECEMBER 1979			
SEWAR	80009	2.85	7.—
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E57: JANUARY 1980			
digital tuning scale (two boards)	80021-1/2	7.05	17.—
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E58: FEBRUARY 1980			
aerial amplifier	80022	1.85	4.50
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bus board 1	80068-1	9.90	23.50
bus board 2	80068-2		
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E59: MARCH 1980			
chorosynth	80060	22.15	53.—
E60: APRIL 1980			
aide-de-camp: 12 V/2 A	7043B	1.10	2.50
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E61: MAY 1980			
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Junior computer:			
main board	80089-1	12.60	30.—
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supply board	80089-3	3.—	7.—
E62: JUNE 1980			
pest pester	80130	1.10	2.50
E63/64: SUMMER CIRCUITS 1980			
STAMP amplifier	80543	1.40	3.50
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E65: SEPTEMBER 1980			
8K RAM + EPROM card	80120	13.15	31.50
E67: NOVEMBER 1980			
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E69: JANUARY 1981			
disco ceiling lights	81012	8.70	20.50
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low voltage board	81085-1	2.30	5.50
main board	81085-2	2.45	6.—
E70: FEBRUARY 1981			
voiced/unvoiced detector			
detector board	81027-1	3.40	8.—
switch board	81027-2	4.05	9.50
2½ digit DVM			
display board	81105-1	2.40	5.50
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E71: MARCH 1981			
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MW receiver	81111	1.95	4.50
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High Com:			
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E73: MAY 1981			
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main board	81094-1	8.35	20.—
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E74: JUNE 1981			
Junior Computer			
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E75/76: SUMMER CIRCUITS 1981			
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E77: SEPTEMBER 1981			
TV games computer			
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E78: OCTOBER 1981			
RF-test generator	81150	1.60	3.80
economical fridge defroster	81158	1.80	4.35
EPROM programmer	81594	1.45	3.50
wide range dark room timer	82004	2.25	5.50
shutter speed meter	82005	3.75	9.—
LCD panel meter	82011	1.65	4.—
universal LED display	82015	1.60	4.—
E79: NOVEMBER 1981			
teletext			
decoder board	82001-2	5.35	12.50
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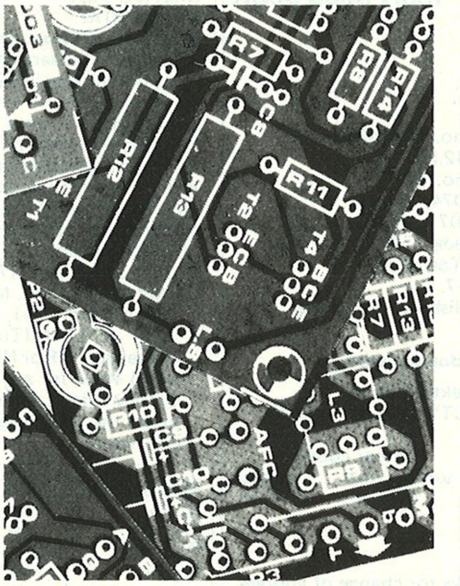

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E80: DECEMBER 1981

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E81: JANUARY 1982

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E82: FEBRUARY 1982

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E83: MARCH 1982

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E84: APRIL 1982

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E85: MAY 1982

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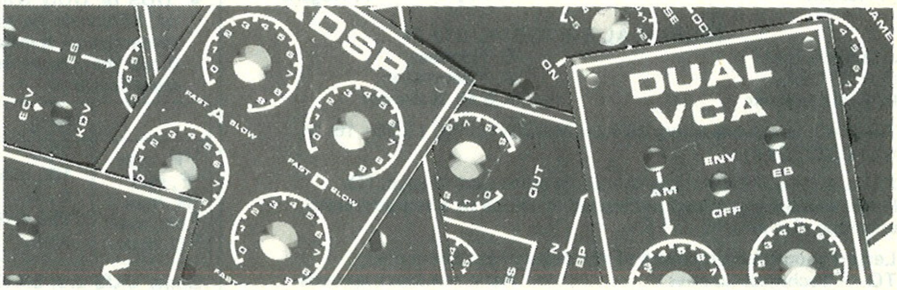

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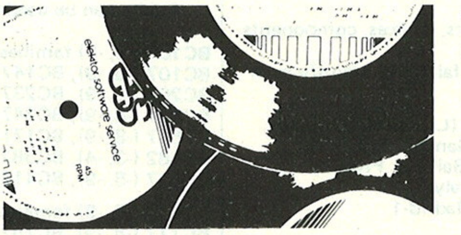

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ABC

decoder

What is a TUN?
What is 10 n?
What is the EPS service?
What is the TQ service?
What is a missing link?

Semiconductor types
Very often, a large number of equivalent semiconductors exist with different type numbers. For this reason, 'abbreviated' type numbers are used in Elektor wherever possible:

- '741' stand for µA741, LM741, MC1741, MIC741, RM741, SN72741, etc.
- 'TUP' or 'TUN' (Transistor, Universal, PNP or NPN respectively) stand for any low frequency silicon transistor that meets the following specifications:

$U_{CEO, max}$	20 V
$I_{C, max}$	100 mA
$h_{fe, min}$	100
$P_{tot, max}$	100 mW
$f_{T, min}$	100 MHz

Some **'TUN's** are: BC107, BC108 and BC109 families; 2N3856A, 2N3859, 2N3860, 2N3904, 2N3947, 2N4124. Some **'TUP's** are: BC177 and BC178 families; BC179 family with the possible exeption of BC159 and BC179; 2N2412, 2N3251, 2N3906, 2N4126, 2N4291.

- 'DUS' or 'DUG' (Diode Universal, Silicon or Germanium respectively) stands for any diode that meets the following specifications:

	DUS	DUG
$U_{R, max}$	25 V	20 V
$I_{F, max}$	100 mA	35 mA
$I_{R, max}$	1 µA	100 µA
$P_{tot, max}$	250 mW	250 mW
$C_{D, max}$	5 pF	10 pF

Some **'DUS'** are: BA127, BA217, BA218, BA221, BA222, BA317, BA318, BAX13, BAY61, 1N914, 1N4148.
Some **'DUG'**s are: OA85, OA91, OA95, AA116.

- 'BC107B', 'BC237B', 'BC547B' all refer to the same 'family' of almost identical better-quality silicon transistors. In general, any other member of the same family can be used instead.

BC107 (-8, -9) families:
BC107 (-8, -9), BC147 (-8, -9), BC207 (-8, -9), BC237 (-8, -9), BC317 (-8, -9), BC347 (-8, -9), BC547 (-8, -9), BC171 (-2, -3), BC182 (-3, -4), BC382 (-3, -4), BC437 (-8, -9), BC414

BC177 (-8, -9) families:
BC177 (-8, -9), BC157 (-8, -9), BC204 (-5, -6), BC307 (-8, -9), BC320 (-1, -2), BC350 (-1, -2), BC557 (-8, -9), BC251 (-2, -3), BC212 (-3, -4), BC512 (-3, -4), BC261 (-2, -3), BC416.

Resistors and capacitor values
When giving component values, decimal points and large numbers of zeros are avoided wherever possible. The decimal point is usually replaced by one of the following abbreviations:
p (pico-) = 10^{-12}
n (nano-) = 10^{-9}
µ (micro-) = 10^{-6}
m (milli-) = 10^{-3}
k (kilo-) = 10^{3}
M (mega-) = 10^{6}
G (giga-) = 10^{9}

A few examples:
Resistance value 2k7: 2700 Ω.
Resistance value 470: 470 Ω.
Capacitance value 4p7: 4,7 pF, or 0.000 000 000 004 7 F . . .
Capacitance value 10n: this is the international way of writing 10,000 pF or .01 µF, since 1 n is 10^{-9} farads or 1000 pF.
Resistors are ¼ Watt 5% carbon types, unless otherwise specified.
The DC working voltage of capacitors (other than electrolytics) is normally assumed to be at least 60 V. As a rule of thumb, a safe value is usually approximately twice the DC-supply voltage.

Test voltages
The DC test voltages shown are measured with a 20 kΩ/V instrument, unless otherwise specified.

U, not V
The international letter symbol 'U' for voltage is often used instead of the ambiguous 'V'. 'V' is normally reserved for 'volts'. For instance: U_b = 10 V, not V_b = 10 V.

Mains voltages
No mains (power line) voltages are listed in Elektor circuits. It is assumed that our readers know what voltage is standard in their part of the world!
Readers in countries that use 60 Hz should note that Elektor circuits are designed for 50 Hz operation. This will not normally be a problem; however, in cases where the mains frequency is used for synchronisation some modification may be required.

Technical services to readers

- **EPS service.** Many Elektor articles include a lay-out for a printed circuit board. Some — but not all — of these boards are available ready-etched and predrilled. The 'EPS print service list' in the current issue always gives a complete list of available boards.
- **Technical queries.** Members of the technical staff are available to answer technical queries (relating to articles published in Elektor) by telephone on Mondays from 13.30 to 16.15. Letters with technical queries should be addressed to: Dept. TQ. Please enclose a stamped, self addressed envelope; readers outside U.K. please enclose an IRC instead of stamps.
- **Missing link.** Any important modifications to, additions to, improvements on or corrections in Elektor circuits are generally listed under the heading 'Missing Link' at the earliest opportunity.

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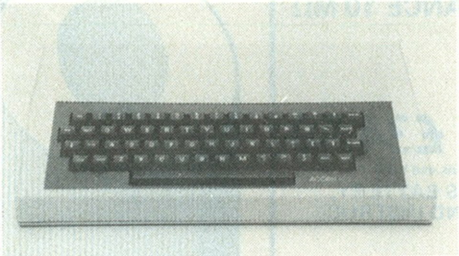

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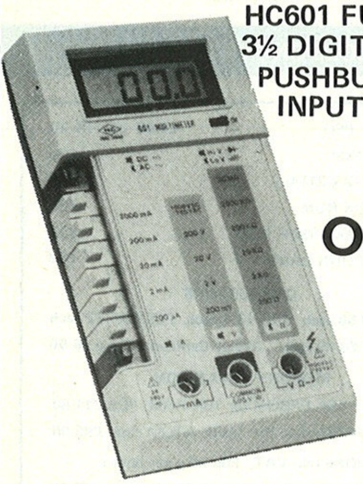

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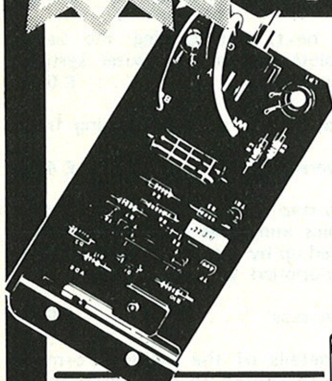

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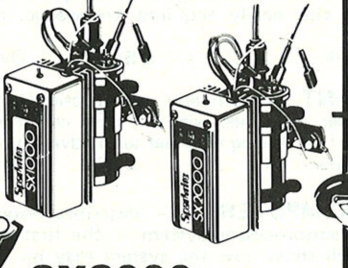

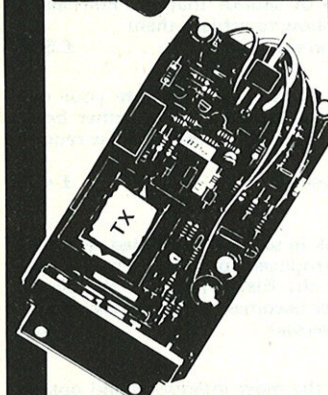

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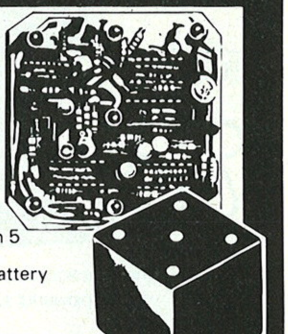

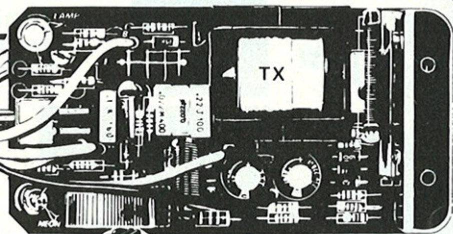

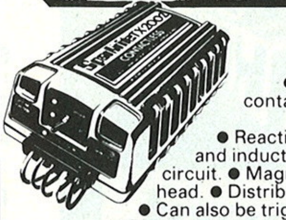

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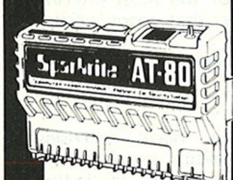

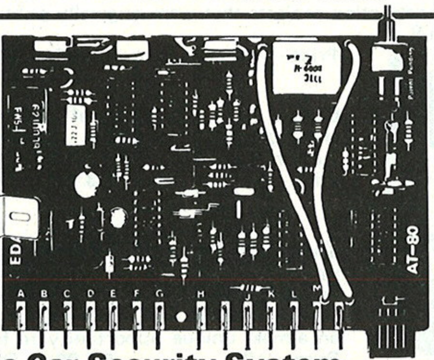

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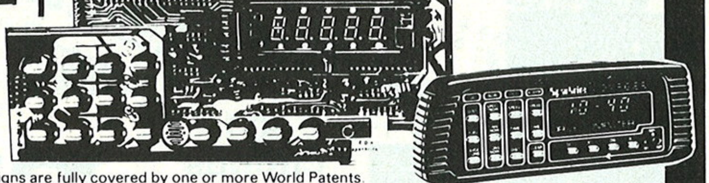

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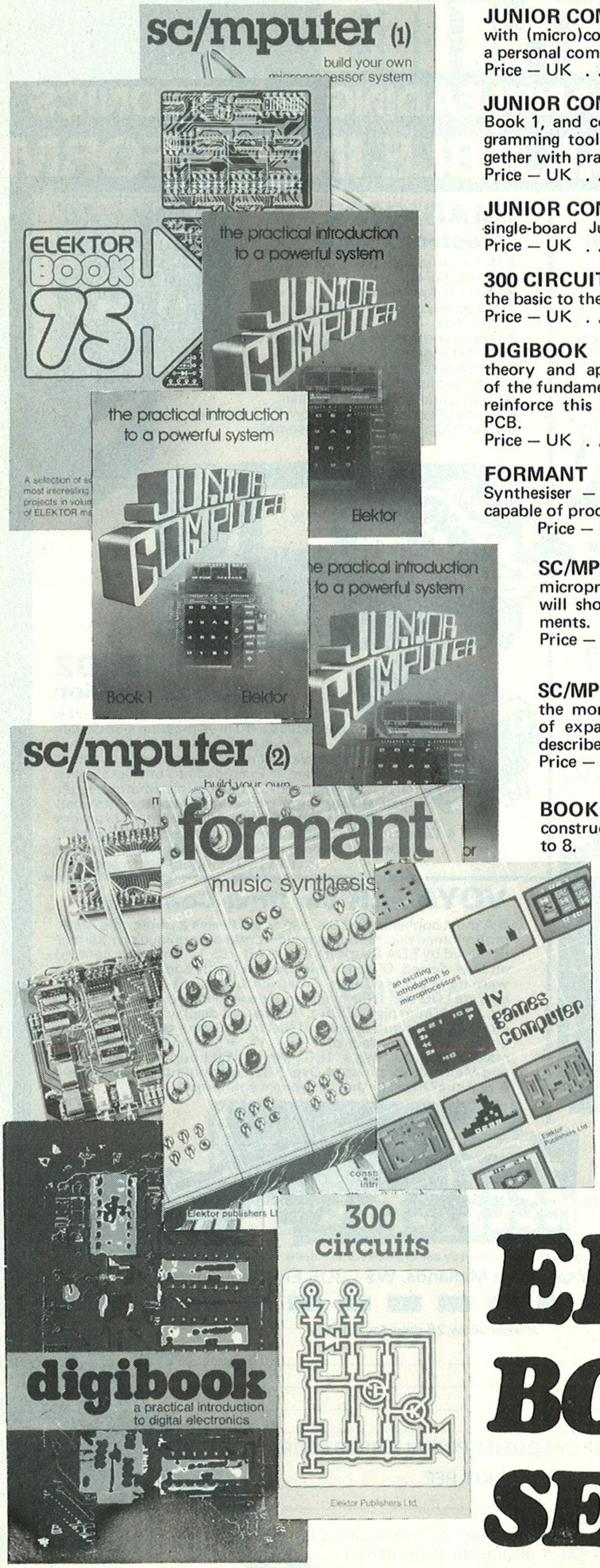
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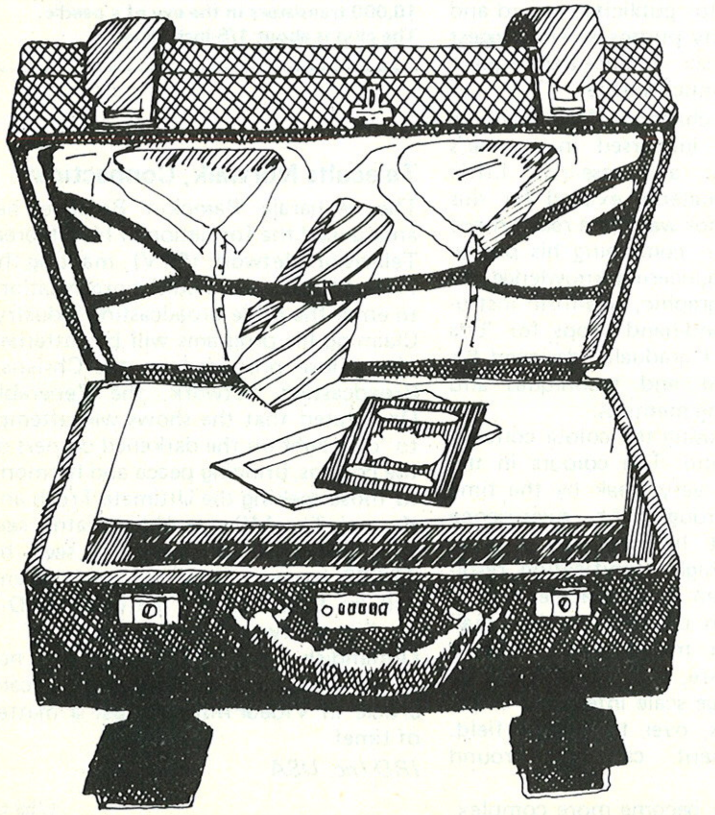

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Photographing the hidden beauty of microchips

Manchester photographer Ad Sternberg is a man fascinated by the delicacy, beauty and colour of microchips. Combining highly sophisticated photographic and engineering techniques he has developed a unique method of photographing in fine detail and enlarging in full colour the integrated circuitry — invisible to the naked eye — of microchips, many little larger in diameter than the dot on a typewriter.

According to Mr. Sternberg, scientists and engineers in electronics have performed wonders in reducing them to a microcosm. A great deal of science and engineering skill is needed in photomicrography not only to produce a detailed negative image for enlargement but also enhanced and with controllable colour contrast.

Colour print examples of Mr. Sternberg's work in the photomicrography of microcircuits — enlarged possibly 400 times are now on display and used by internationally-known companies such as Plessey, Standard Telecommunications, International Computers, National Semi-Conductor and Ferranti Electronics.

Mr. Sternberg's methods have been developed with special regard to photography of micro-circuits up to 8 mm (0.3 inches) diagonal, using a diffraction limited system.

Camels may not be able to go through the eye of a needle, microchips — which today provide the circuitry used in computers, space craft, rocket missiles, telecommunications and more humble objects such as cookers and washing machines — certainly can. Absolute cleanliness is vital. The tiniest particles of dust would produce big black blobs.

Mr. Sternberg has been interested in photography since teenage. He joined an industrial and commercial photographic business in 1947, having previously spent some years learning to work to fine tolerances in an engineering tool factory. When silicon chips — microchips — arrived on the industrial scene in the 1960s he was approached by Ferranti who asked if he could, at reasonable cost, improve on the quality of the results they were getting themselves with colour photographs of silicon chips, wanted for publicity, record and internal company purposes. The biggest 'chips' were six millimetres square — others being much smaller.

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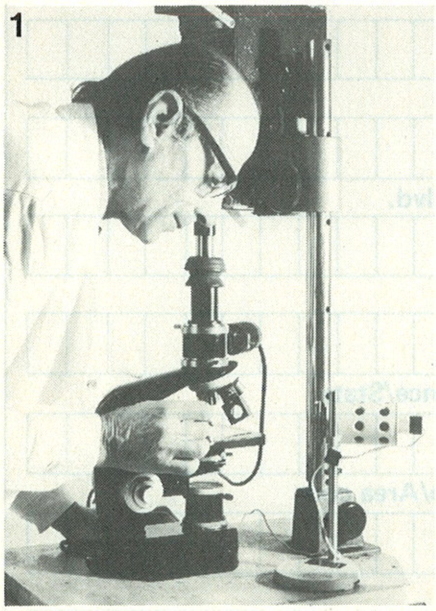

Photo 1. Ad Sternberg using a microscope to select a chip for photography.

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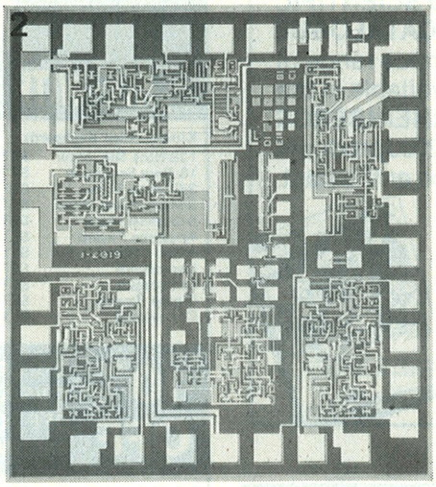


Photo 2. A typical Ferranti small integrated circuit photographed and enlarged by Ad Sternberg.

Taking up the challenge, Mr. Sternberg found himself immersed in a year's experimentation and research. Little photographic material existed for this type of work, nor was there ready-made equipment. But, combining his photographic and engineering knowledge, he combed photographic, scientific instrument and second-hand shops for 'bits and pieces, and gradually designed his own equipment and techniques and colour processing methods.

A way of increasing the colour contrast had to be found. The colours in the microchips are very weak by the time they pass through the microscope optics. Correct lighting was a great problem. With high magnification, resolution figures can now be achieved that are better than one micron for small devices half a millimetre — around 20 thou — square, and better than four microns for large scale integrated chips, known as LSIs, over the whole field. The enlargement can be around 400 times.

The chips have become more complex, of course, over the years. They pack more and more on one chip. Nowadays, computers have to be used to design the circuits because they are too complicated for even the finest scientists without computer aid. They have thousands of transistors and resistors on them. Mr. Sternberg believes, with good reason, that his equipment, methods and experience in this unusual field make his work unique — and that the techniques developed are applicable to photomicrography and photomacrography in general. Of course he realises there are other people in this field, particularly in the United States. However, it calls for quite a blend of different expertise not only in photography but also in engineering, optics and illumination — and dedication over a long period — to produce relatively low-cost results.

3

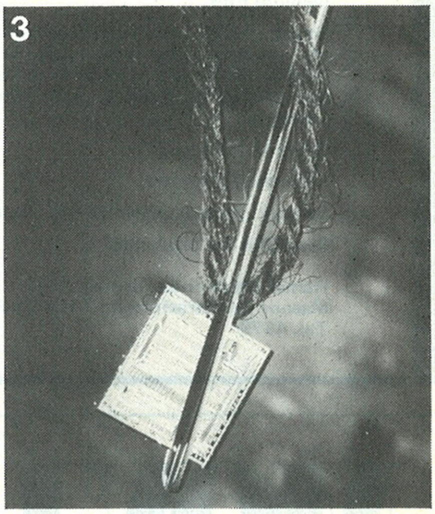


Photo 3. A Ferranti F100L microprocessor chip, containing approximately 10,000 transistors in the eye of a needle. The chip is about 1/5-inch square.

Telecults Norwalk, Connecticut

The Maharaja Pampkin Bolanee has announced the formation of his Ethereal Television Network (ETV), marking the first of the so-called cultist organisations to enter the cable broadcasting industry. Claiming his programs will be patterned after those produced by the Christian Broadcasting Network, the Venerable One stated that the shows will attempt to 'cast light on the darkened corners of the cosmos, bringing peace and harmony to those seeking the Ultimate Truth and Karma'. The 146-year old mohatma said that ETV can currently be seen by 43,000 homes across the country and will be broadcast via the Comstar D-2 satellite thirty-six hours per week.

Outlandish, you say? Perhaps, but not at all unlikely. According to a recent article in VideoPrint, it's just a matter of time!

IRD Inc. USA

(759 S)

selektor

LaserVision in the UK

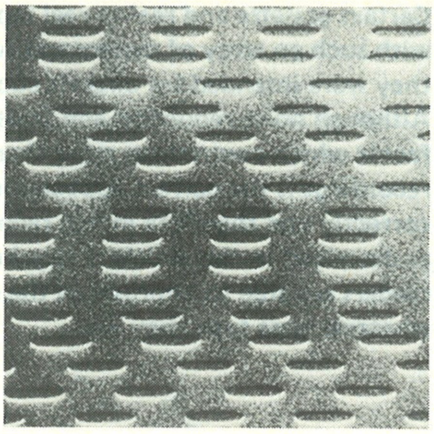
Philips intend to launch its LaserVision Disc system onto the UK market towards the end of May this year.

To start with, players and discs will be on sale in greater London and the surrounding home countries through a restricted number of outlets. These will include high street multiples, independent retailers and specialist rental companies. Philips plan to progressively increase the number of outlets into other major cities in the UK until distribution reaches a nationwide level at the earliest opportunity.

The first catalogue will contain more than 100 disc titles of which at least 75 will be in the shops by May. The remaining catalogue titles will become available shortly afterwards. Further new releases will substantially expand the catalogue by the end of the year. Seven top programme distributors will be marketing a wide range of titles on disc from the initial catalogue, including feature films, general entertainment programmes, musicals, sport and children's albums.

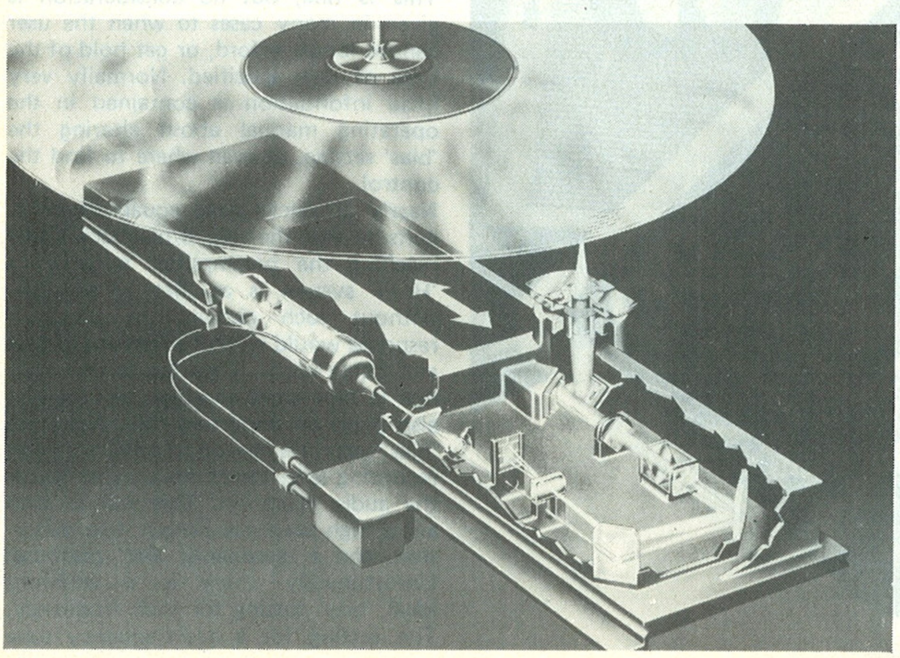
A strong advertising and promotional campaign has been set up with the intention of communicating the LaserVision message in an accurate and straightforward manner so that it may be understood at all levels of trade and by the consumers. LaserVision is a new and unique source of home entertainment and information for all the family.

The easy-to-operate, damage-proof design of the player and the durable quality of the toughcoated discs allow the equipment to be used by everyone, even children.



Not only is Philips committed to developing the consumer market, but the company plans to enter the non-domestic market as well, as this offers considerable scope for the interactive application of LaserVision on the industrial, commercial and educational level.

(766 S)



250 kW Wind turbine

The need for alternative energy resources is not only a favourite discussion topic, but is at last leading to concrete results. Which of the elements (sun, sea or wind) is suitable for producing energy depends to a large extent on the local climate. Not surprisingly, solar energy can be found in abundance in deserts like the Sahara or in Arizona. Unfortunately, the British Isles do not have much sun to offer, but they are visited (and sometimes plagued) by plenty of sea breezes and gales, an inexhaustible source of fuel.

Wind energy projects are starting to be developed on an increasingly large scale, one of the most ambitious schemes to date being the wind turbine generator designed by the Wind Energy Group for installation on Orkney. The Wind Energy Group comprises British Aerospace Dynamics Group, GEC Energy Systems Limited and Taylor Woodrow Construction Limited. The company has signed an agreement with the North of Scotland Hydro-Electric Board to construct the most powerful wind turbine generator ever built in the United Kingdom. It is to be erected on Burgar Hill, Orkney.

The 20 m diameter turbine has a rated power of 250 kilowatts (kW) at 17 metres/second (m/s) wind speed and a rotational speed of 88 revolutions/minute (rev/min). It will begin to operate at a wind speed of 8 m/s and shut down when wind speeds exceed 27 m/s. It has an estimated annual energy output of 700,000 kilowatt-hours (kWh). The machine is to have a synchronous generator, variable pitch rotor blade tips and a soft power transmission arrangement. Provision is being made for the machine to run in both fixed speed and variable speed modes. The rotor will be mounted to the main shaft with what is known as a teetering hub. This arrangement reduces the forces and moments on the blades and supporting structure.

The machine will be the first in the UK in recent times to be connected to an isolated diesel-electric grid system, and with a power rating of 250 kW will be the most powerful turbine to be connected in such a way anywhere in the world. These factors made its economic and technical evaluation especially relevant to many hundreds of similar grid systems elsewhere in the world who are burdened with large generating costs.

The Group has paid particular attention to this potential market in designing the transmission and control system of the machine to achieve power quality acceptable to a small diesel grid system. The prototype will allow for tests to evaluate fixed versus teetering hubs, constant versus variable speed operation, as well as a wide range of operational strategies. The machine is to be extensively monitored under a contract with the Department of Energy using a computer based data acquisition system which will scan sensors placed on the machine to measure performance, forces and displacements.

Procurement of components is now taking place prior to assembly and ground testing of the nacelle and rotor in the last quarter of 1982, while construction of the foundation and tower will begin in the summer. Commissioning and first synchronisation of the machine is schedules for the first quarter of 1983.

The 250 kW machine also acts as the prototype for the larger machine which will be 60 m in diameter. When complete the project will be the largest demonstration in the UK of an alternative energy technology.

(768 S)

Certain cassette and reel-to-reel tape decks and recorders are equipped with such an array of meters and switches that some look as though they were intended for aircraft cockpits rather than for home use. Although noise reduction and equalisation circuits are necessary, the factor which contributes more than anything else to the quality of recordings is the correct application of 'BIAS'. In order to set the 'bias' correctly and therefore match recorder to tape, a signal generator, as described in this article is required. Armed with such a generator, readers are able to improve on the quality of recordings and use whatever tape type they wish.

test tone generator

how to set the 'BIAS' on your tape recorder

The existing range of decks and tapes is enormous. In an attempt to get over some of the confusion and conflicting sales literature, manufacturers tend to specify which type of tape will get the best performance out of their decks. This is fine, but no consideration is given in many cases to when the user can no longer afford, or get hold of the type of tape specified. Normally very little information is contained in the operating manual about altering the 'bias' setting, or even where to find the control.

Nearly all decks have equalisation circuits so that the record/playback signal reaching the preamplifier stage of a 'Hi Fi' system is as 'flat' as possible. Without such circuits the playback response would exhibit pronounced bass and treble losses. These losses are partly due to tape speed and type, but the bias also plays an important role. A correct 'bias' setting is needed to achieve a good recording level for all frequencies across the audio spectrum. This will in turn allow high playback output, low distortion, and a reasonably 'flat' response. Unfortunately there is a different ideal 'bias' setting for each frequency. The setting for a mid-frequency tone

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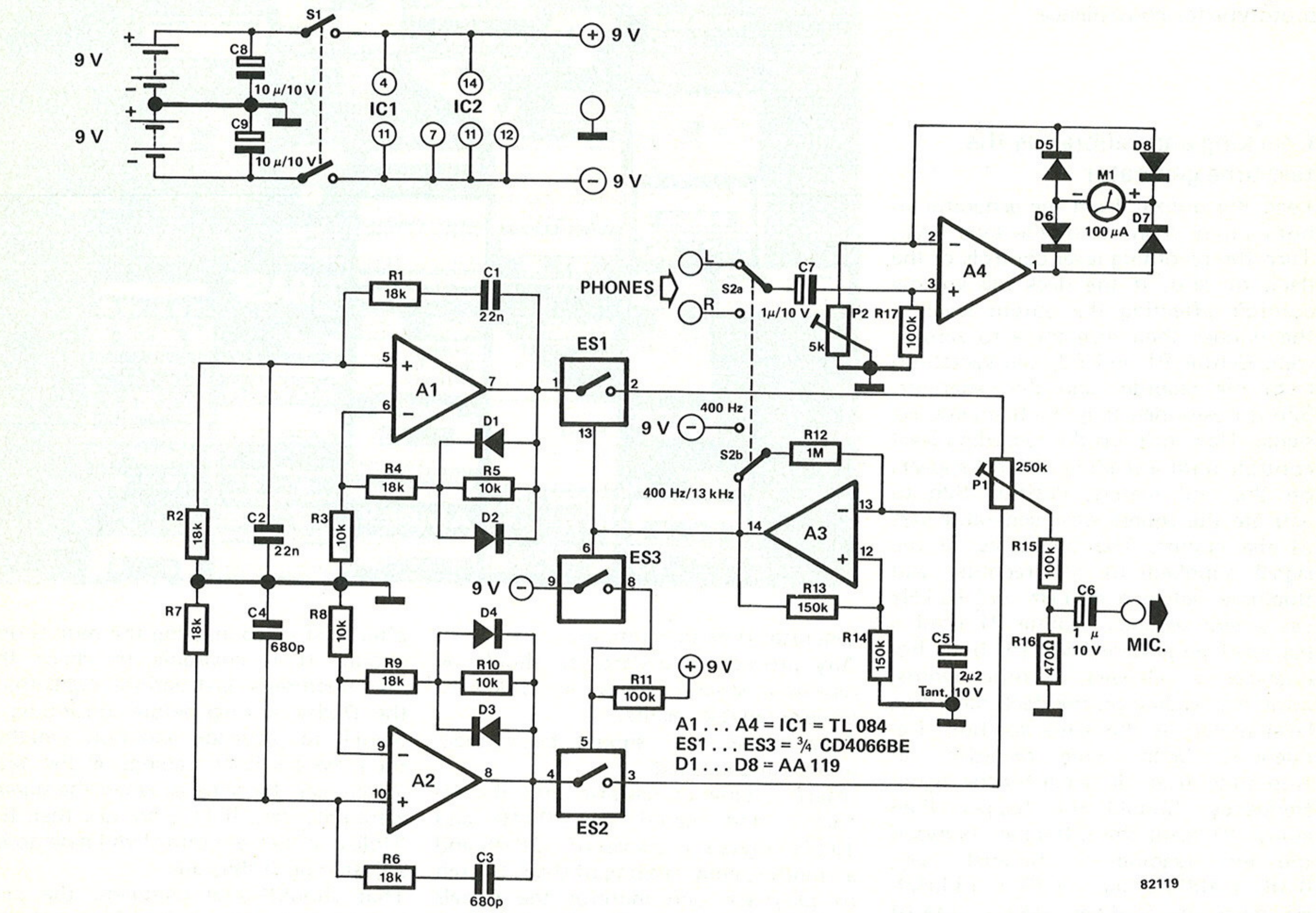


Figure 1. The circuit diagram of the complete tone generator and a suitable power supply circuit. Readers are advised to use 'Veroboard' as the construction medium.

(400 Hz) is quite different from the one required for a 13 kHz signal. Generally speaking, the higher the frequency the lower the 'bias' level. Therefore tape deck manufacturers specify the type of tape to use and choose a 'bias' setting (out of necessity) which is a compromise. A real in depth study of 'bias' is certainly not practical at this stage, as it would probably take up most of this issue. Anyway, we are more interested in practice than in theory.

Tone generator

As outlined above a test tone generator supplying a mid and low frequency signal is necessary. Figure 1 shows the circuit diagram of the generator. It mainly consists of two bridge oscillators. The first one, arranged around A1, produces a practically distortion-free sine wave signal of 400 Hz. Stabilisation is achieved by using germanium diodes. The second oscillator (constructed around A2) operates in the same way, but produces a 13 kHz signal. Both signals are fed in turn to the output stage by means of the CMOS switches ES1 and ES2. The circuit around A3 functions as a square wave generator with a frequency of about 0.25 Hz, activating the electronic switches in such a way that the output will alternate between 400 Hz and 13 kHz every two seconds.

With a positive pulse, ES1 and ES3 are closed and the 400 Hz signal reaches the output. With a negative going pulse ES1 and ES3 are open and ES2 is closed allowing the 13 kHz signal to be fed to the output. Preset P1 ensures the output amplitude for each signal is the same. The network made up of R15, R16 and C6, in the output stage, sets the impedance and level of output so that it can be fed directly to the 'mike' input of the deck.

The fourth opamp A4 is used to drive a dB level meter for monitoring purposes. A moving coil instrument or a multimeter set to the 100 µA range is sufficient. Preset P2 sets the gain of A4. With the help of S2a the signal taken from the headphone socket of the deck can be monitored, one channel at a time. By switching over S2b the square wave generator is by-passed and only the 400 Hz signal reaches the output. Two completely separate switches can be used for S2a and S2b. A single double-pole one was only used in the prototype for convenience.

Checking and calibrating the test tone generator

Feed the output from the generator to both input channels of the tape deck. Turn the recording level controls of the deck to zero. If the deck has volume controls affecting the output level to the phones then turn these to zero as well. Centre P1 and P2, and switch on both the recorder and the generator. S2b is positioned to give a fixed 400 Hz signal. Now turn up the recording level controls until a reading of 0 dB appears on the 'vu' meters. Position S2b to activate the square wave generator part of the circuit. The frequency of the signal supplied to the recorder will fluctuate between 400 Hz and 13 kHz every two seconds. Rotate P1 until a balanced amplitude level for both frequencies is achieved, in other words, until the reading on the deck recording level meters is the same for both frequencies. With some recorders an amplitude drop will occur for the higher frequency. Should this happen then adjust P1 until the difference between the two readings is minimal, (say, 0 dB at 400 Hz and –3 dB at 13 kHz). Whatever the readings, take a note of them as they will come in handy later on.

Set the recording levels of the recorder to –20 dB and adjust P2 to give a monitor reading of 0 dB.

Using the generator

Before going any further the following points should be kept in mind.

Before adjusting the 'bias' give the generator time to warm up.

Any procedures undertaken should be repeated several times in order to achieve reliable results.

Tape heads, etc. should be de-magnetised and cleaned.

Insert a tape or cassette into the recorder, and record the 400 Hz and 13 kHz signals at a level of –20 dB and a monitor meter reading of 0 dB. Switch to playback and monitor the signals again for each channel and note if they are the same as the recorded ones. These should be approximately 0 dB or as previously noted (0 and –3 dB).

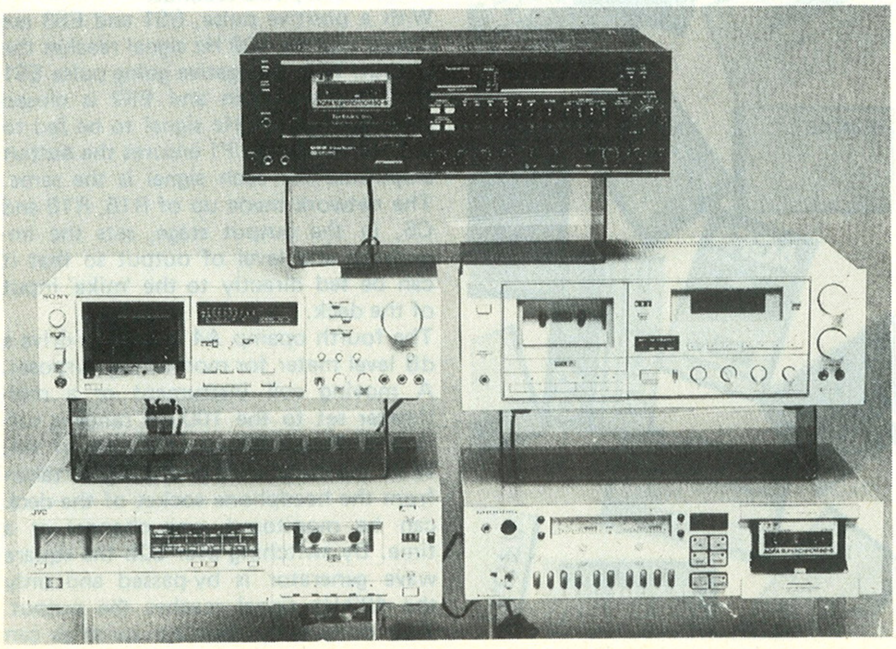
Any deviation in readings will mean that the 'bias' setting will have to be altered. Therefore change this setting and repeat the procedures until the correct readings appear. The 'bias' setting will now be correct for the particular tape in use.

To set the 'Dolby' frequency roll-off level, first record only the 400 Hz tone, after first disconnecting the monitoring circuit. It is advisable to check the manufacturer's instructions concerning the 'Dolby' settings before continuing. Switch to playback and note whether the playback level readings on the deck meters are the same as when the signals were recorded. If they are not then the 'Dolby' preset or control will have to be adjusted until they are.

That should now complete the procedures necessary to interface with the particular tape in question.

Practical hints

Readers are reminded that the lower priced reel-to-reel and cassette recorders do not have an external 'bias' control. The lucky ones with middle and up-market models will certainly have these, making calibration far easier. For the unlucky ones it is best to consult a circuit diagram or other data in order to locate the presets inside the recorder. The 400 Hz tone is also very useful as a 'bench-mark' in the calibration of 'equalisation' and other audio circuits. ◼



polyphonic synthesiser

U. Götz and R. Mester

the digital keyboard assembly and debounce circuitry

The general principles and basic theory behind the new Elektor polyphonic synthesiser were introduced in the March 1982 issue. However, this article is devoted to the practical side, namely the constructional details, thereby enabling readers to commence building. We start off with the debounce circuitry for the keyboard contacts and the input unit (together with its bus board) which acts as the keyboard interface for the main CPU card.

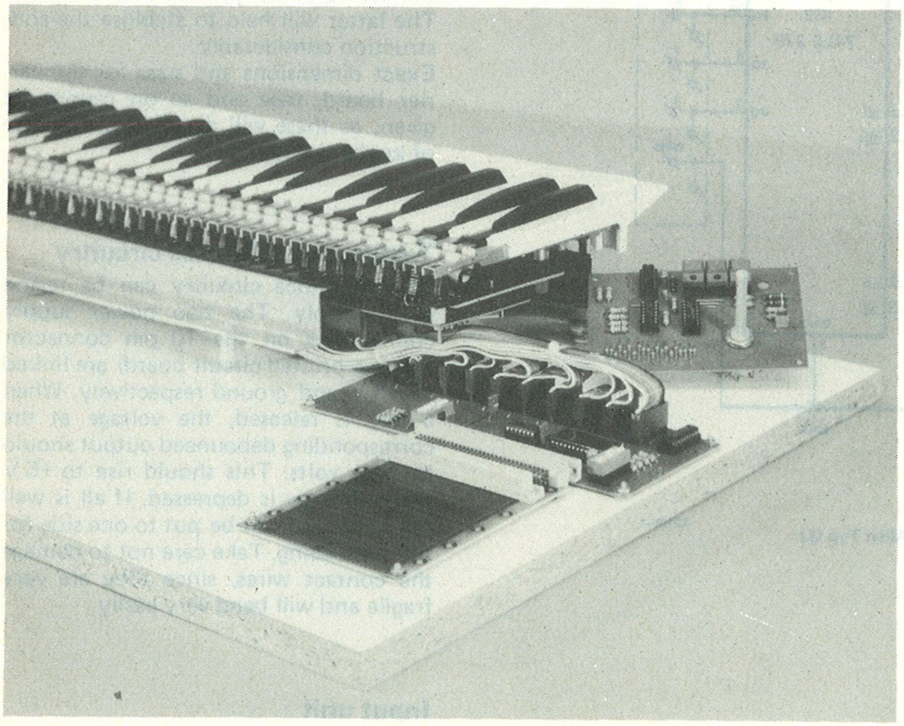


Photo 1. This photo shows how the debounce unit, the input unit, the tune-shift unit and the bus board are mounted and wired.

The digital keyboard design caters for up to five octaves (61 keys). Although it is obviously possible to use fewer keys, the relatively small price difference between three and five octave keyboards prompted the designers to go for the latter. This also means that the range of musical possibilities can be exploited to the full. The keyboard contact blocks, or switches, are mounted on eight individual printed circuit boards in seven groups of eight and one group of four. Each board also contains the debounce circuitry for its respective keys. The contact blocks used are the (gold wire) single pole GJ type from Kimber Allen.

The debounce circuitry for each key consists of an RS flipflop. There are ten connections between each printed circuit board and the input unit, 8 for the debounce circuitry and 2 for the power supply.

By now, readers will have noticed that only half of the eighth printed circuit board is used, meaning that only 60 of the 61 keys can be used (see figure 8). A close examination of the debounce circuitry in figure 1 and the printed circuit board layouts in figures 5, 6 and 7 should provide a clue, however. Effectively, the 8 printed circuit boards are identical. The 8 keys on each board are subdivided into two groups of four. The reason for this is that the design had to fulfil the main conditions of optimum performance and value for money, while being simple to construct. In reality, the keys at the extreme ends of the keyboard are very rarely used anyway. If readers wish to use the lower key rather than the higher one, all that needs to be done is to shift the connections down one key (or semitone). This does not present too much of a problem, since the VCOs of the individual channels can be adjusted to give the required pitch.

If all 61 keys are to be used, then the 8th printed circuit board will have to be fully utilised. This does mean, however, that the printed circuit board assemblies would protrude from the side of the keyboard, making it more difficult to fit the unit into a case. To make construction easier and for space considerations, we suggest that the last board is cut in two and the unused half discarded (see figure 8). This means, of course, that the relevant connections on the input board will have to be grounded. In practice, this is accomplished by earthing the four respective pins on the ten-pin connector. If this was not carried out, the processor would be confused into thinking that the non-existing keys were permanently depressed!

Mechanical construction

The keyboard contact blocks are mounted on the underside of the board (see figure 3). Position the blocks (notch side towards the board) on the printed circuit board and glue them into place. A good strong adhesive such as Araldite

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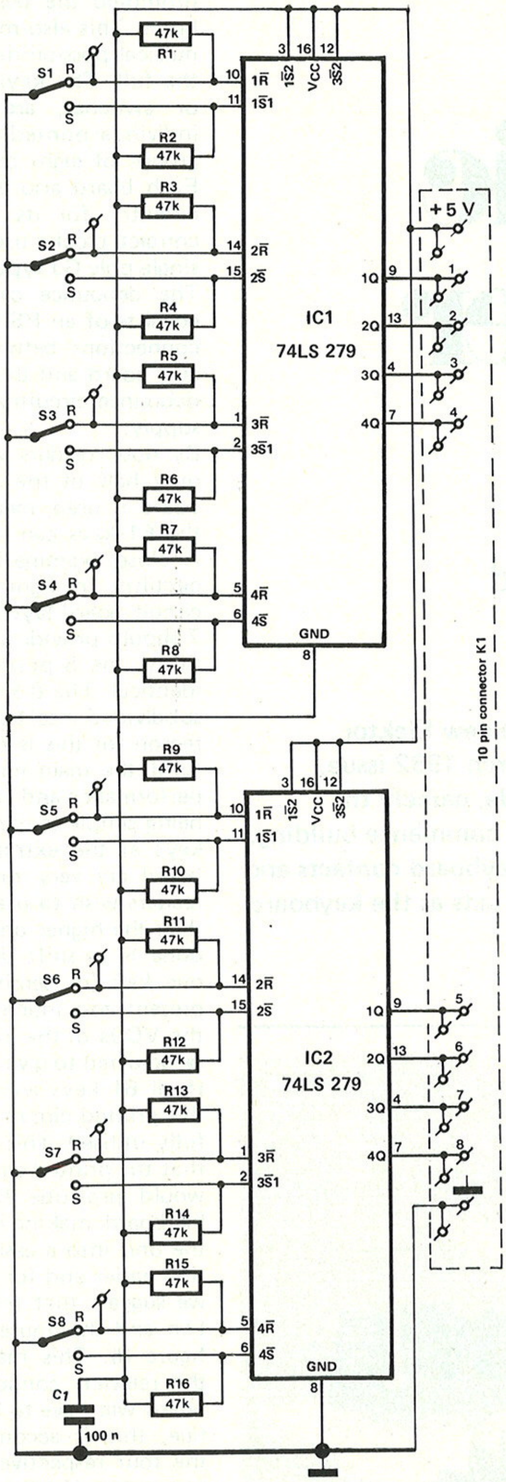

Key contacts: Kimber-Allen Typ GJ

Figure 1. The keyboard debounce circuitry.

should be used. The adhesive should be applied sparingly taking care not to get any near the contact wires. Bend the short wires at the rear of the blocks towards the board and solder them into place. It is important to remember that the contact blocks must be wired so that the circuit is closed when the key is depressed.

The next step is to drill a hole in a convenient place near the centre of each printed circuit board. This hole should be large enough to allow a self-tapping screw and the blade of a screwdriver to pass through it. The reason for this is so that the carrier board can be mounted directly to the keyboard chassis (this is explained later on).

All the other components, including the 10 pin connector, are then mounted on the boards. The 8 ((7½ actually) boards are now ready to be assembled on to the carrier board, by means of suitable nuts, bolts and spacers. The length of the spacers should not exceed the overall height of the contact blocks, which is approximately 9.5 mm with the types specified.

The carrier board is then attached to the keyboard chassis. The spacing between the carrier board and the chassis is very important. The key push rods are often in 'fishplate' form (see figure 2) so as to allow the centre contact spring to be located in one of the holes. It is essential that the centre contact spring touches the upper contact when the key is depressed.

Most keyboard chassis' are not predrilled, therefore readers must decide for themselves where the carrier board is to be attached. Self-tapping screws are ideal for this operation, which brings us back to the holes previously drilled in the centre of the printed circuit boards. The latter will help to stabilise the construction considerably.

Exact dimensions and sizes for the carrier board, case and so on cannot be given, as these will depend on the type of keyboard used.

Testing the debounce circuitry

The debounce circuitry can be tested quite simply. The two power supply connections on the 10 pin connector (of one printed circuit board) are linked to +5 V and ground respectively. When a key is released, the voltage at the corresponding debounced output should be zero volts. This should rise to +5 V when the key is depressed. If all is well the keyboard can be put to one side for the time being. Take care not to damage the contact wires, since they are very fragile and will bend very easily.

Input unit

The input unit shown in figure 3 consists basically of an 8 bit data bus over which the processor is able to read in

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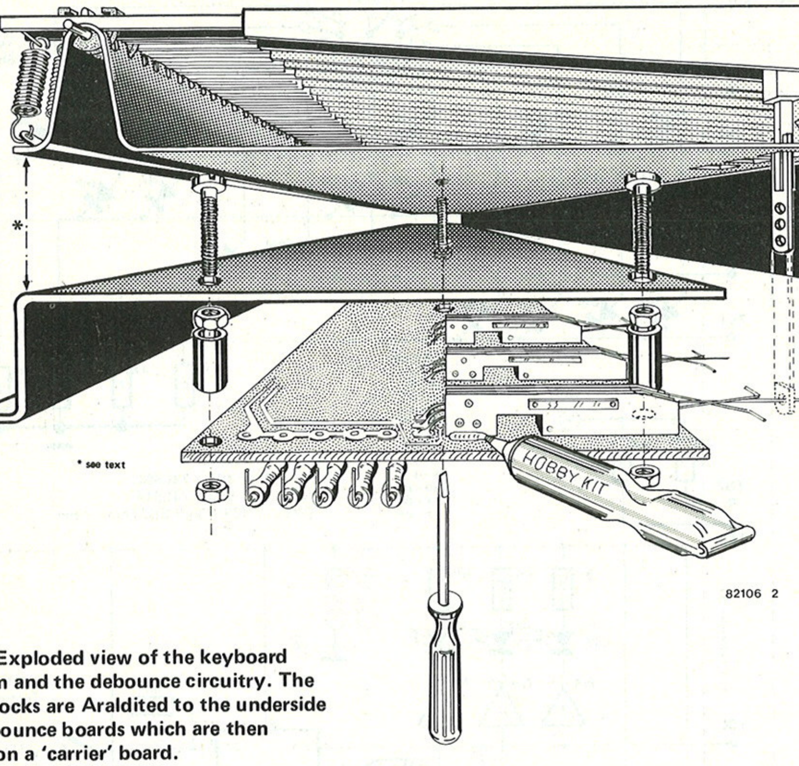

Figure 2. Exploded view of the keyboard mechanism and the debounce circuitry. The contact blocks are Araldited to the underside of the debounce boards which are then mounted on a 'carrier' board.

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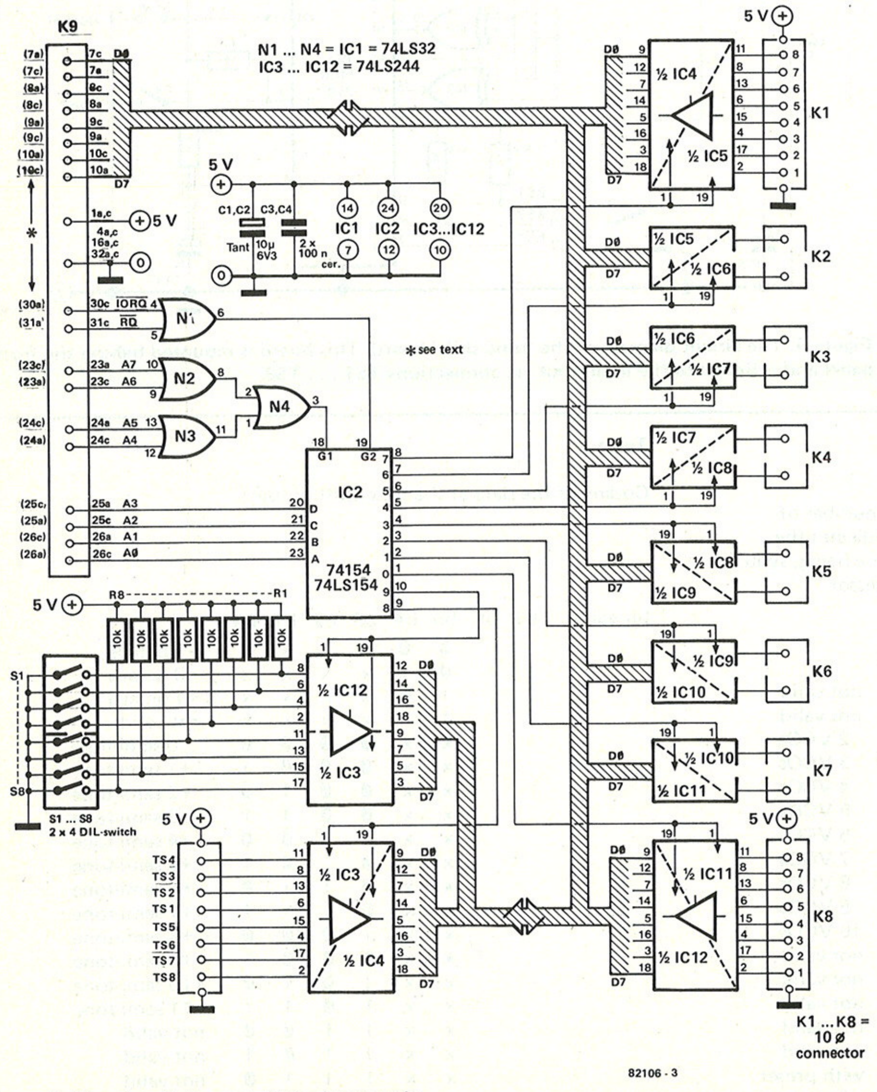

Figure 3. The circuit diagram of the input unit.

data (by means of multiplexing) via the buffer stages, IC3 . . . IC12. The outputs of these buffers are held in a high impedance state until such time as the devices are enabled by means of the signal presented to pins 1 and 19.

Address lines A0 . . . A7 originate from the microprocessor and are decoded via gates N1 . . . N4 and IC2 to produce the select signals for the data buffers. This means that only one data buffer will be enabled at a time and the processor will always 'know' exactly which one is being addressed.

As the data and address lines are common to both the input and the output units, the input data will have to be disabled when the output unit is being accessed. This is accomplished by gating the $\overline{RD}$ and $\overline{IORQ}$ signals from the microprocessor and feeding the resultant signal to one of the select inputs of IC2.

The construction of digital data processing systems can be kept simple and small, by using a common highway for multiple data transfer (this is a typical procedure in computer systems). It is interesting to know what the data presented to the microprocessor looks like. The inputs of the majority of the buffer ICs are connected to the outputs of the debounce circuitry. The processor scans the buffer ICs one by one by means of the chip enable inputs (pins 1 and 19) so that it can determine exactly which, if any, key is being depressed.

The buffer consisting of half of IC3 and half of IC12 is used by the microprocessor to determine the number of VCOs which are available in the synthesiser. As mentioned previously, any number of VCOs between 2 and 10 can be incorporated. The eight DIL switches, S1 . . . S8 are used to preset this number according to the information given in table 1.

The connections TS1 . . . TS8 lead to the 'tune-shift' board, which is shown in figure 4. A diode matrix ensures that the correct logic levels are presented to the data bus when switch S1 is operated. In this way the VCO frequencies can be transposed by one octave, one semitone at a time. Three pushbutton switches, S2 . . . S4, connected to the tune-shift circuit determine the 'direction' in which the notes are shifted. The logic levels required by the system software are presented to the data bus via connections TS5 and TS6. Of the four possible set/reset latches contained in IC1, only three are used to effectively 'decode' the state of the three switches (latches 1, 2 and 4). Under normal conditions, S3 will have been depressed and the output of the first latch (1Q) will be high whereas the outputs of the other two (2Q and 4Q) will be low. Now, if S2 is depressed, the output of the second latch (2Q) will go high and the other two latches will be reset via gates N2 and N3. Similarly, if S4 is depressed, output 4Q goes high and latches 1 and 2 are reset via gates N1 and N2. Gates N1 and N3 are used to reset latches 2 and 4 when switch S3 is depressed. The current 'state of affairs' is indicated by the three LEDs (D21 . . . D23) connected to the latch outputs via inverters N4 . . . N6. These LEDs are mounted inside the switches. The remaining latch in IC1 (latch 3) may be used in the future for expanding the keyboard.

The CPU card and the output unit with its corresponding digital-to-analogue (D/A) conversion system will be described in subsequent articles.

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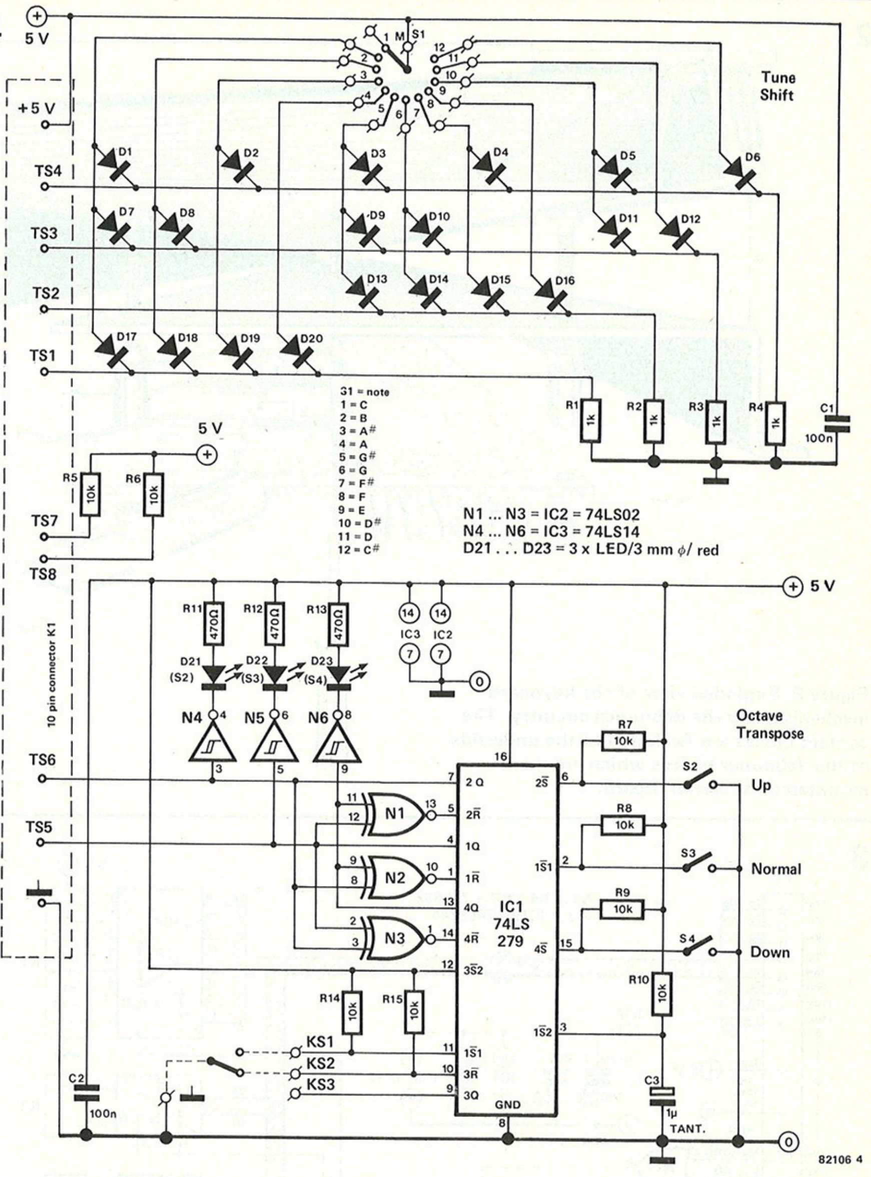


Figure 4. The circuit diagram of the 'tune-shift' board. This board is mounted behind the front panel and is linked to the input unit via connections TS1 . . . TS8.

Table 1

The coding for switches S1 . . . S8:
Switches S1 . . . S4 (bits b0 . . . b7) represent the number of available oscillators in binary. Switch S5 (bit 4) indicates the presence/absence of the preset facility. For the time being, switches S6 . . . S8 (bits b5 . . . b7) are ignored by the processor.

switch number	S8	S7	S6	S5	S4	S3	S2	S1	
bit value:	b7	b6	b5	b4	b3	b2	b1	b0	
					0	0	0	0	not valid
					0	0	0	1	not valid
					0	0	1	0	2 VCOs
					0	0	1	1	3 VCOs
					0	1	0	0	4 VCOs
					0	1	0	1	5 VCOs
					0	1	1	0	6 VCOs
					0	1	1	1	7 VCOs
					1	0	0	0	8 VCOs
					1	0	0	1	9 VCOs
					1	0	1	0	10 VCOs
					1	0	1	1	not valid
					1	1	0	0	not valid
					1	1	0	1	not valid
					1	1	1	0	not valid
					1	1	1	1	not valid
				0	x	x	x	x	with preset
				1	x	x	x	x	without preset

Table 2

Coding of the data at the tune-shift output:

bit value:	b7	b6	b5	b4	b3	b2	b1	b0	
			0	0	x	x	x	x	−1 octave
			0	1	x	x	x	x	0 octave
			1	0	x	x	x	x	+1 octave
			1	1	x	x	x	x	not valid
			x	x	0	0	0	0	0 semi-tone
			x	x	0	0	0	1	+1 semi-tone
			x	x	0	0	1	0	+2 semi-tone
			x	x	0	0	1	1	+3 semi-tone
			x	x	0	1	0	0	+4 semi-tone
			x	x	0	1	0	1	+5 semi-tone
			x	x	0	1	1	0	+6 semi-tone
			x	x	0	1	1	1	+7 semi-tone
			x	x	1	0	0	0	+8 semi-tone
			x	x	1	0	0	1	+9 semi-tone
			x	x	1	0	1	0	+10 semi-tone
			x	x	1	0	1	1	+11 semi-tone
			x	x	1	1	0	0	not valid
			x	x	1	1	0	1	not valid
			x	x	1	1	1	0	not valid
			x	x	1	1	1	1	not valid

5

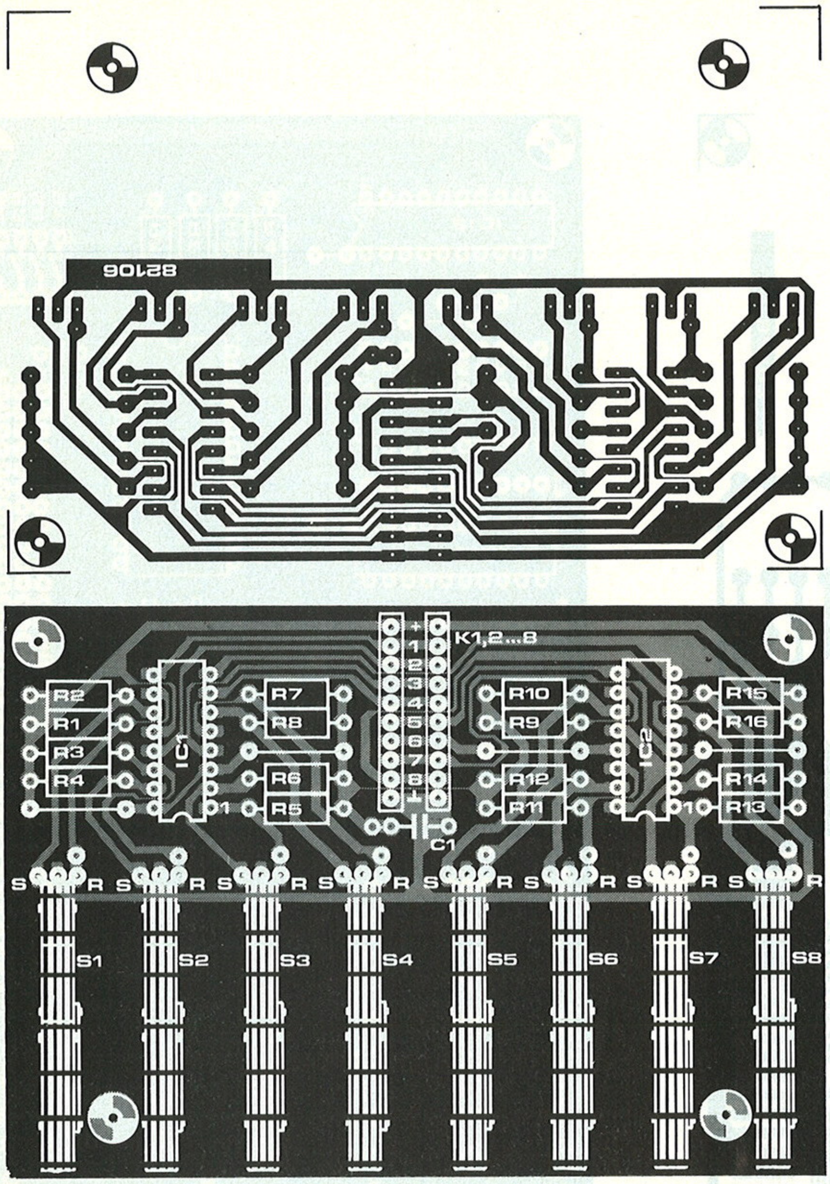
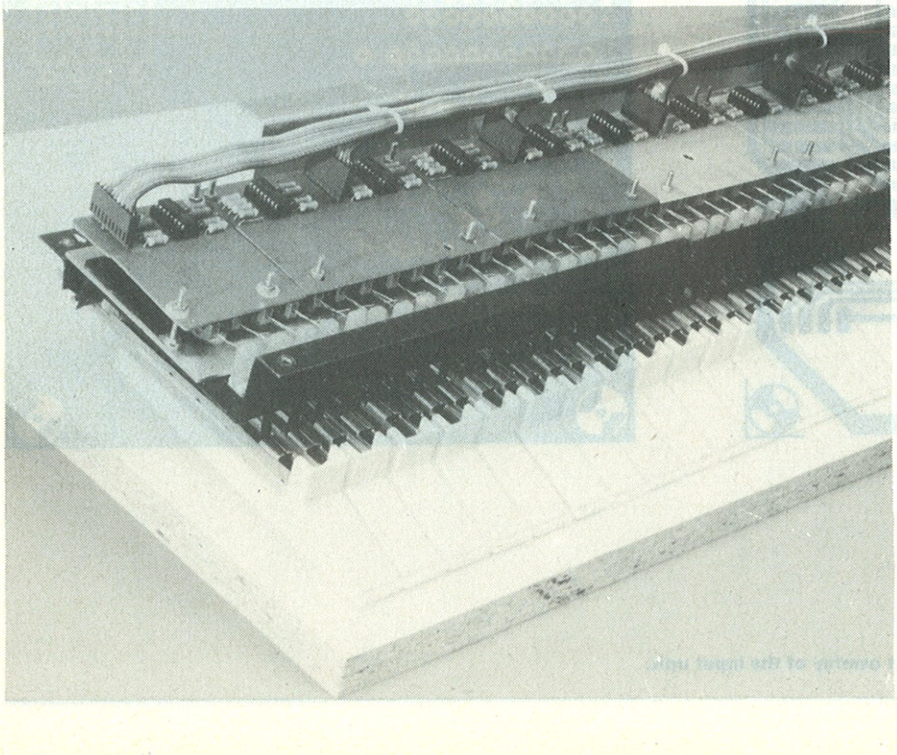


Figure 5. The printed circuit board and component overlay of the debounce unit.



Parts list for figures 1 and 5

Resistors:
R1 . . . R16 = 47 k

Capacitors:
C1 = 100 n ceramic or MKT

Semiconductors:
IC1,IC2 = 74LS279

Miscellaneous:
8 key contacts (Kimber Allen (gold wire)/ type GJ/single pole)
10 pin plug (Molex male E 3022-10A)
10 pin socket (Molex female E 3071-10)
10 crimp terminals (Molex 4809 CL)
Note: all of the above are required eight times

Parts list for figures 3 and 6

Resistors:
R1 . . . R10 = 10 k

Capacitors:
C1 = 10 μ/6.3 V tantalum
C2 . . . C4 = 100 n ceramic or MKT

Semiconductors:
IC1 = 74LS32
IC2 = 74LS154
IC3 . . . IC12 = 74LS244

Miscellaneous:
S1 . . . S8 = 2 x 4 way DIL switches
9 ten-pin plugs and sockets and crimp terminals (see parts list for the debounce unit)
angled 2 x 32 way plug (DIN 41612)

Parts list for figures 4 and 7

Resistors:
R1,R2 = 1 k
R5 . . . R10,R14,R15 = 10 k
R11 . . . R13 = 470 Ω

Capacitors:
C1,C2 = 100 n ceramic or MKT
C3 = 1 μ/6.3 V tantalum

Semiconductors:
D1 . . . D20 = 1N4148
D21 . . . D23 = 3 mm red LED (in digitast switches S2 . . . S4)
IC1 = 74LS279
IC2 = 74LS02
IC3 = 74LS14

Miscellaneous:
S1 = single pole 12 way rotary switch
S2 . . . S4 = digitast (with LEDs)
10 way plug, socket and crimp terminals (see parts list for debounce unit)

6

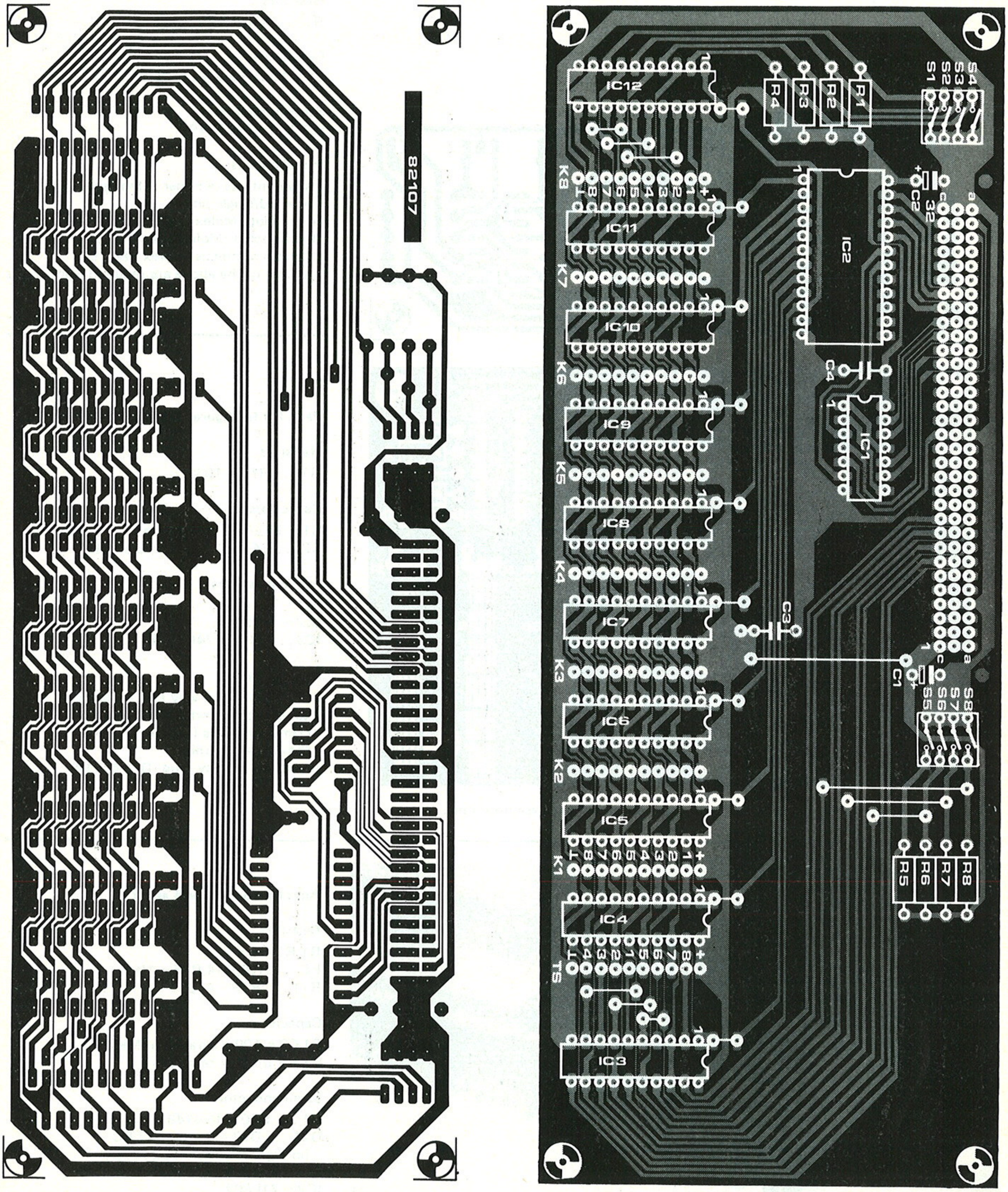


Figure 6. The printed circuit board and component overlay of the input unit.

7

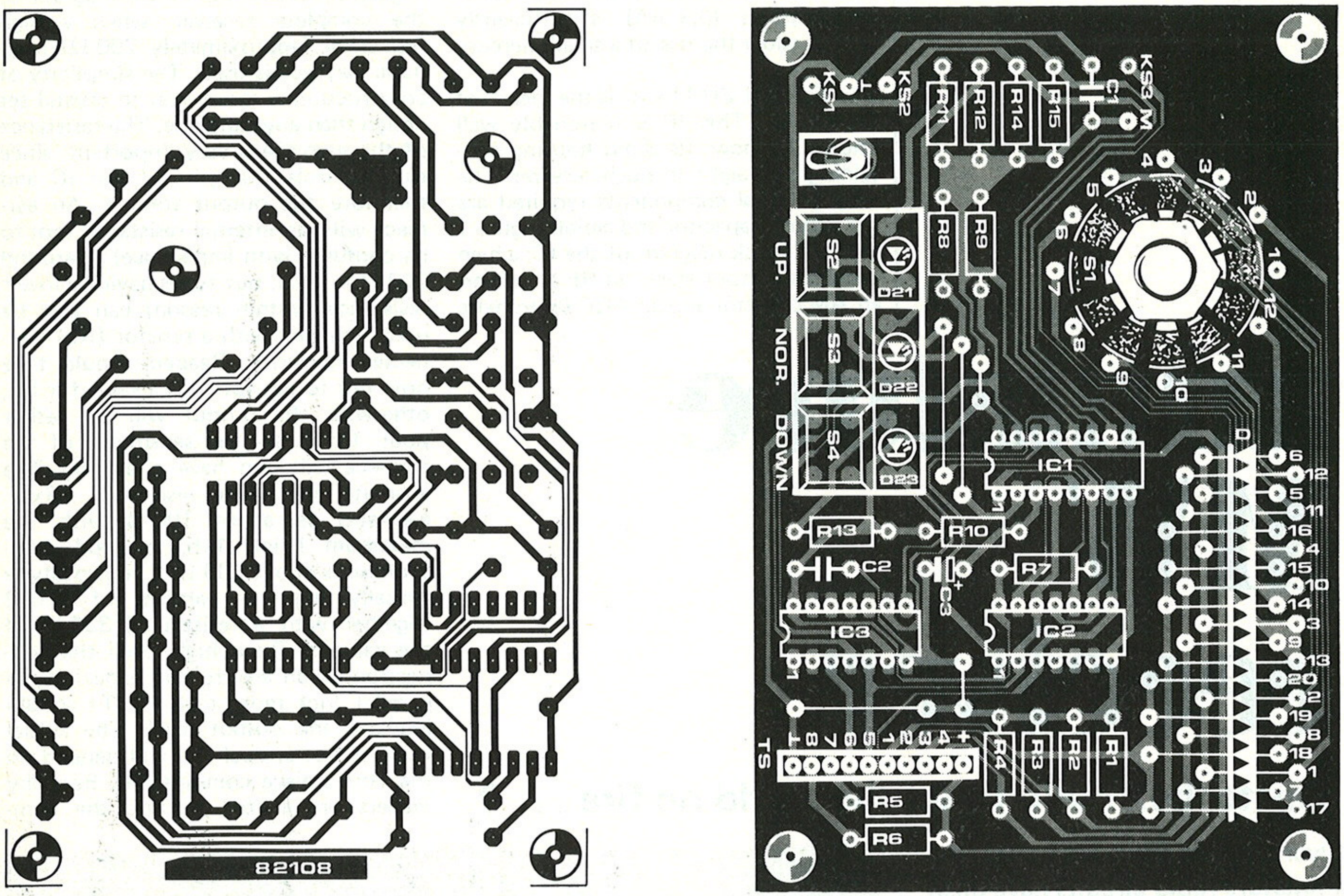


Figure 7. The printed circuit board and component overlay of the 'tune-shift' unit.

8

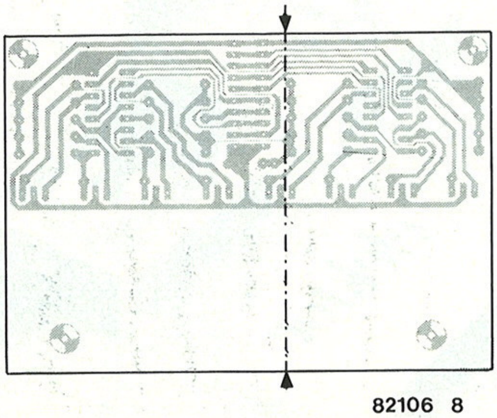


Figure 8. A section of figure 5 showing where the 8th debounce board can be sawn in two without damaging the copper tracks.

The system has been designed such that the existing Elektor bus board (EPS number 80024) can be used to link the CPU card and the input/output units. A suitable method of mounting the various parts of the system are shown in the photograph. ◄

miniature MW receiver

a matchbox radio to set the world on fire . . . ?

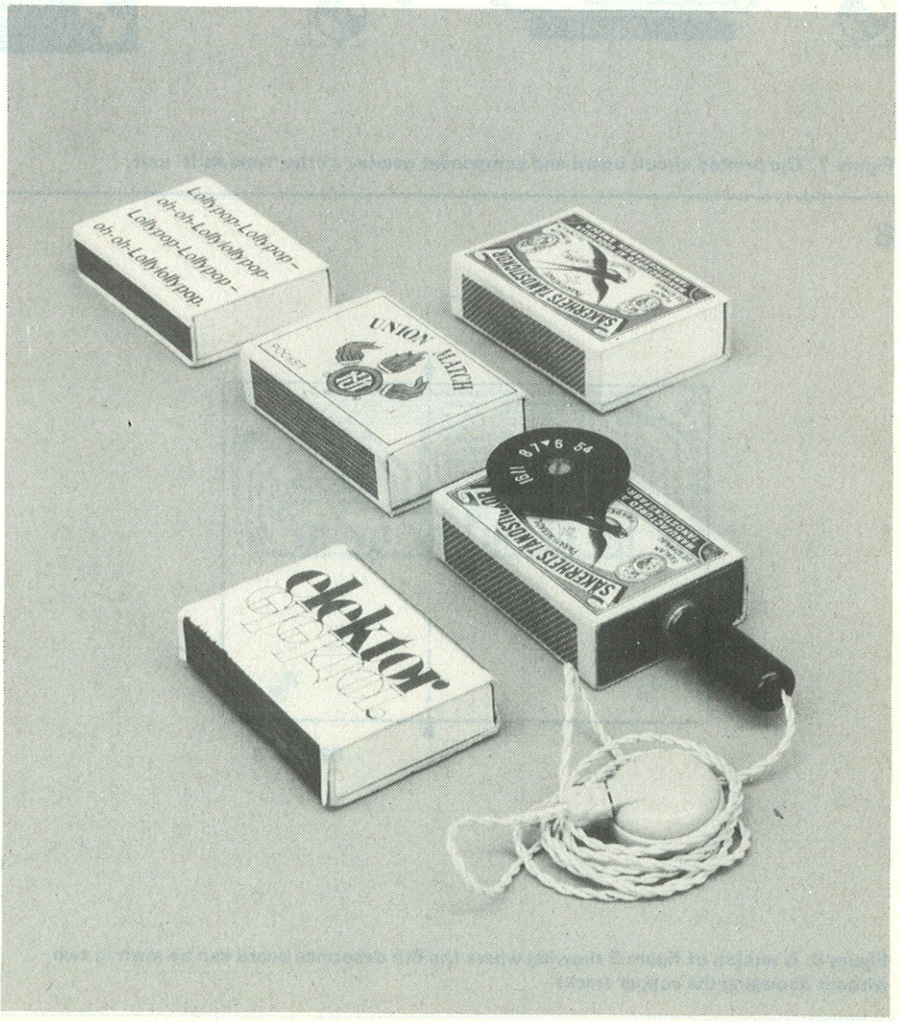
Over the past fifty years a lot of miniature radio circuits have been designed. Unfortunately most of them have suffered from a lack of output power and sensitivity. Furthermore the majority always had problems with the aerial. Readers may remember the wrist watch type radios that came to the fore some time ago, when an aerial had to be wound around the wrist or in the strap. Anyway, very few of them gave a worthwhile performance.

With the advent of the ZN 414, designs became simpler and better. Using this well-proven chip, the article introduces a straightforward circuit with very few components which can outperform many equivalent commercially produced sets. It has good output power, reception and selectivity.

The design is based on the MW receiver circuit which was published in March 1981. This circuit lends itself very well to miniaturisation because it requires very few components and the power consumption (0.3 mA) is sufficiently low to allow the use of a small mercury cell.

The Ferranti ZN 414 IC is the 'heart' of the circuit. This IC is reasonably well known by now, its 3 pin housing containing a straight through receiver. The only external components required are the tuning capacitor and aerial. Figure 1 shows a block diagram of the IC; a high impedance input stage, an RF amplifier, an AM detector and an AGC (automatic gain control). Readers wishing to know more about the inner workings of the ZN 414 are referred to the March 1981 issue of Elektor.

Figure 2a shows the circuit diagram of the complete receiver, when a high resistance (approximately 200 Ω) magnetic earpiece is used. The simplicity of construction is more akin to crystal set design than anything else. The resistance of the earpiece is very important, since this controls the gain of the IC and therefore the output volume. An earpiece with an internal resistance (not to be confused with impedance) of around 200 Ω is ideal, but types having a lower resistance (within reason) can also be used, together with a resistor (Rx) connected in series. Readers should take note not to use too high a value for Rx, otherwise the output will be rather poor. Obviously the sensitivity of the earpiece will also have a bearing. The absolute minimum resistance (Rx + earpiece) is about 100 Ω with the maximum being 1k5. A good compromise is about 500 Ω. The prototype actually used an earpiece of 170 Ω together with a resistor of 330 Ω. If the value of Rx is high, then the connection of an electrolytic capacitor, in parallel (not more than 10 μF) should improve the output level. The actual value is not critical and will depend on the Rx/earpiece combination. Basically readers are invited to find the com-


Lollypop-Lollypop-oh-oh-Lollylollypop-Lollypop-Lollypop-oh-oh-Lollylollypop
UNION MATCH
elektor

1

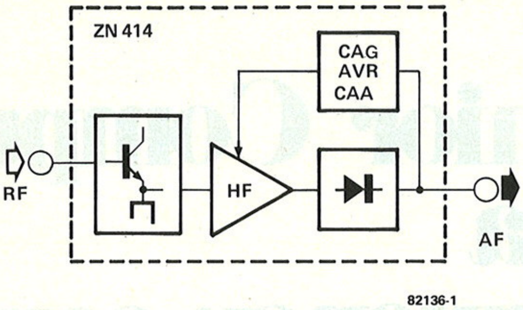


Figure 1. The block diagram of the interior of the ZN 414. This tiny IC forms the basis of the matchbox receiver.

2

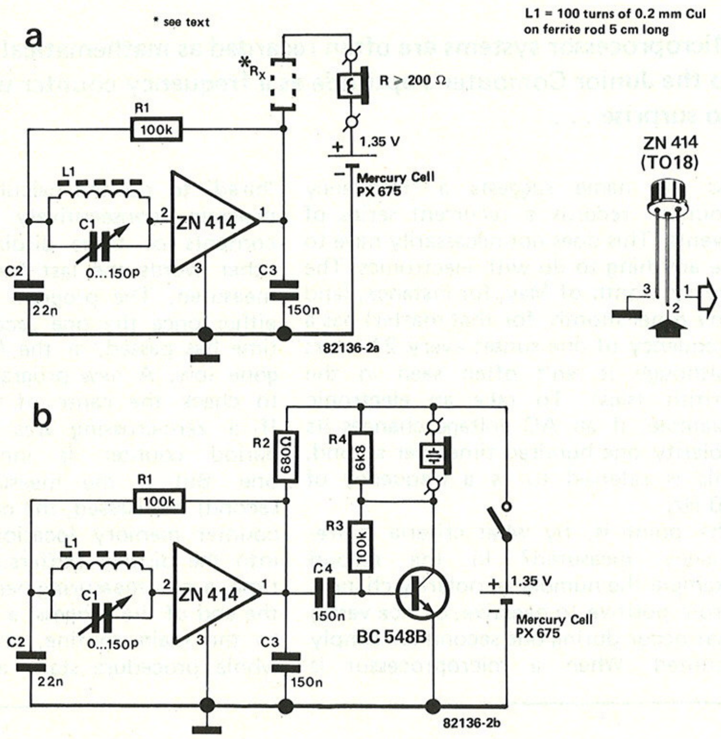


Figure 2. The basic circuit (a) uses a high impedance magnetic earpiece. An output stage is required if a crystal earpiece is to be used (b).

bination applicable to their needs, as it really depends on what output level is required.

Unfortunately the frequently used 8 Ω type is not suitable as it requires the addition of a matching transformer. A high impedance crystal earpiece on the other hand, requires an additional output stage, as shown in figure 2b. The power consumption in both circuits (2a & 2b) is practically the same, because the additional stage (figure 2b) only adds an extra 0.1 mA drain on the battery.

A decoupling capacitor for the power supply is not required, since the internal resistance of the mercury cell is extremely low.

Construction

The choice of housing is left to the reader as it will depend on the size of the components. The prototype was inserted into a matchbox (see photo) simply as a guide-line and to give an impression of its relatively small size. The original design has a flat ferrite rod, 50 mm in length with a cross-section of 12 x 4 mm, but any rod approximately 10 mm in diameter will suffice. The aerial coil is made up of 100 turns of 0.2 mm enamelled copper wire, wound onto a paper or cardboard former. The ferrite rod is inserted into it. The variable capacitor is one of the twin-ganged variety (141 pF and 59 pF) commonly used by manufacturers in commercially available medium wave pocket radios. Should readers wish to have a lower number of windings or use a ferrite rod with an unusual permeability factor, they are advised to connect both gangs in parallel.

As everyone will agree, to design a printed circuit board for this radio would be futile, as that would probably take up more space than the complete

3

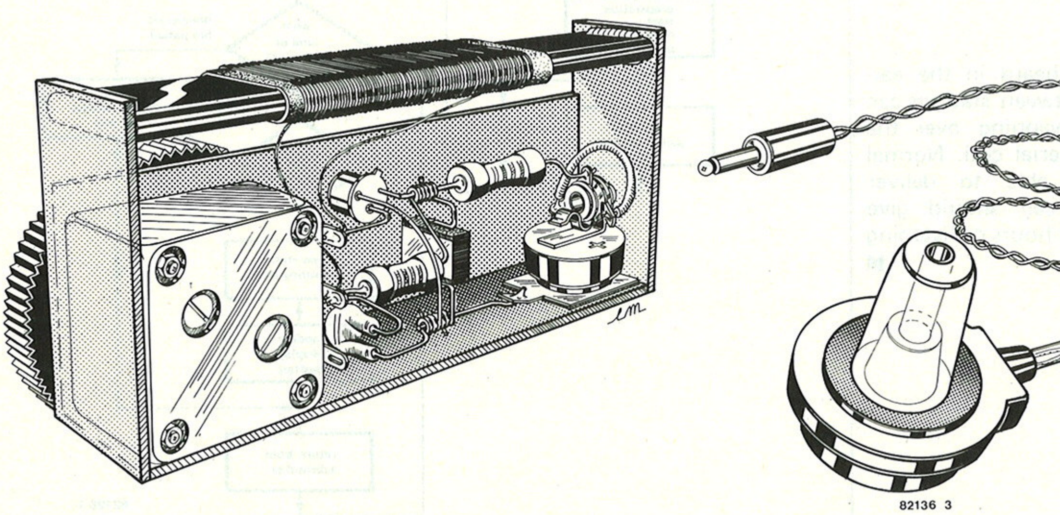
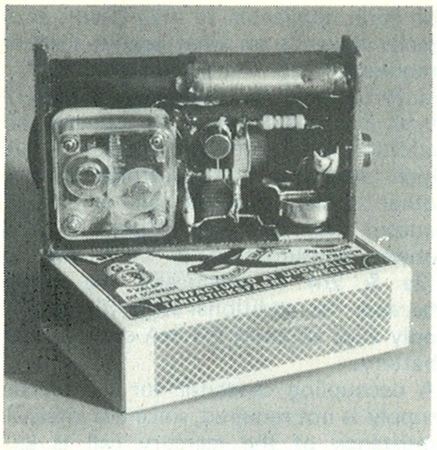


Figure 3. The construction of the matchbox radio is illustrated here. The 'chassis' is made from plastic sheet and fits inside a matchbox. There is plenty of room for all the components including the output stage if required.



radio. It is more convenient to interconnect the components directly. Figure 3 shows one method for this.

The 'chassis' is made of plastic having the same dimensions as the 'tray' of a matchbox. The variable capacitor is mounted onto the chassis by means of appropriate screws. The ferrite rod is attached by glueing each end to the sides of the chassis.

A standard earphone socket is used. Normally the switch part acts to isolate the loudspeaker, but in this case it is utilised as a battery connection. The moving contact part of the switch is cut off with pliers or a wire cutter to leave only the fixed terminal. This serves as the positive contact for the battery. A small brass plate (glued to the side of the chassis) serves as the negative contact. The position of the socket is determined by the size (width) of the battery.

Note that an on/off switch is not necessary when constructing the circuit as in figure 2a. The supply is automatically switched on when the earpiece is plugged in. However, the circuit as in figure 2b does require a switch.

The battery should be a mercury type cell such as a 'Mallory' supplying 1.35 V.

Final remarks

A whine or whistle heard in the earpiece when tuning between stations can be eliminated by swapping over the connections to the aerial coil. Normal mercury cells are able to deliver 200 mAh, so each cell should give between 400 and 500 hours of listening pleasure. ◆

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the Junior Computer as a frequency counter

G. Sullivan

Microprocessor systems are often regarded as mathematical wizards, so the Junior Computer's aptitude as a frequency counter will come as no surprise . . .

As the name suggests a 'frequency counter' records a recurrent series of events. This does not necessarily have to be anything to do with electronics. The merry month of May, for instance, (and any other month, for that matter) has a frequency of one sunset every 24 hours (although it isn't often seen in the British Isles). To take an electronic example, if an AC voltage changes its polarity one hundred times per second, this is referred to as a frequency of 50 Hz.

The point is, by what criteria is frequency measured? In the second example the number of polarity changes (from positive to negative, or vice versa) that occur during one second are simply counted. When a microprocessor is 'hired' to do the calculation work, a program consecutively displays the contents of three display buffers, in other words the last frequency to be measured. The program is interrupted either once the one second measuring time has passed, or the AC voltage has gone low. A new program is now run to check the cause of the interrupt. If a zero-crossing was involved, the period counter is incremented by one. But if the measuring time (1 second) has passed, the contents of the counter memory locations are copied into the display buffers. At the same time, a new measuring period begins. At the end of the process, a return is made to the main routine, after which the whole procedure starts all over again.

1

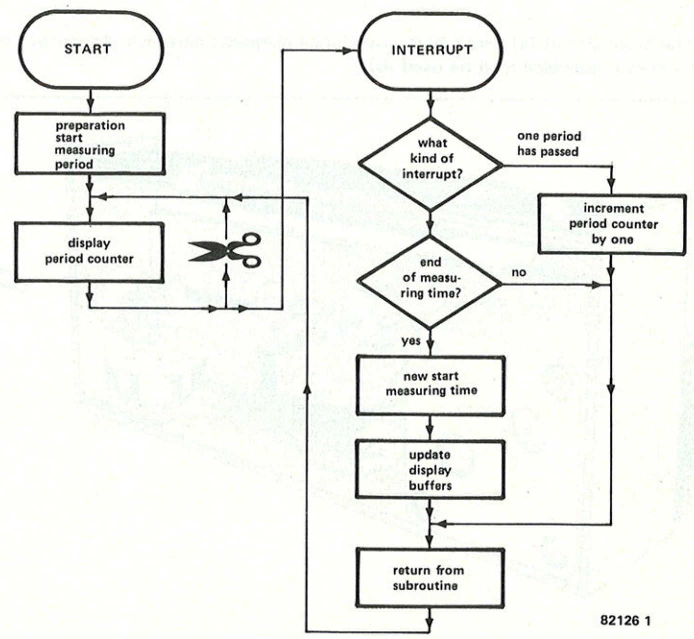


Figure 1. A series of interrupts (IRQ) are required for frequency measurement.

```
$1A00 A9 00      INITPR LDAIM $00
$1A02 85 D0             STAZ  ACCUL
$1A04 85 D1             STAZ  ACCUM
$1A06 85 D2             STAZ  ACCUH
$1A08 A9 29             LDAIM IRQSRV
$1A0A 8D 7E 1A          STA   IRQL
$1A0D A9 1A             LDAIM IRQSRV/256
$1A0F 8D 7F 1A          STA   IRQH
$1A12 8D E6 1A          STA   EDETC
$1A15 A9 10             LDAIM $10 (16₁₀)
$1A17 85 D4             STAZ  TIMEH
$1A19 85 D3             STAZ  COUNT
$1A1B A9 3D             LDAIM $3D (61₁₀)
$1A1D 85 D5             STAZ  TIMEL
$1A1F 8D FF 1A          STA   CNTH
$1A22 58                CLI
$1A23 20 8E 1D LOOP     JSR   SCANDS
$1A26 4C 23 1A          JMP   LOOP
$1A29 48         IRQSRV PHA
$1A2A 8A                TXA
$1A2B 48                PHA
$1A2C 98                TYA
$1A2D 48                PHA
$1A2E 2C D5 1A          BIT   RDFLAG
$1A31 10 1C             BPL   ADD
$1A33 A5 D5             LDAZ  TIMEL
$1A35 8D FF 1A          STA   CNTH
$1A38 C6 D3             DECZ  COUNT
$1A3A D0 28             BNE   EXIT
$1A3C A2 02             LDXIM $02
$1A3E A0 00             LDYIM $00
$1A40 B5 D0      STORE  LDAZ  ACCUL,X
$1A42 95 F9             STAZ  INH,X
$1A44 94 D0             STYZ  ACCUL,X
$1A46 CA                DEX
$1A47 10 F7             BPL   STORE
$1A49 A5 D4             LDAZ  TIMEH
$1A4B 85 D3             STAZ  COUNT
$1A4D D0 15             BNE   EXIT
$1A4F F8         ADD    SED
$1A50 18                CLC
$1A51 A5 D0             LDAZ  ACCUL
$1A53 69 01             ADCIM $01
$1A55 85 D0             STAZ  ACCUL
$1A57 A5 D1             LDAZ  ACCUM
$1A59 69 00             ADCIM $00
$1A5B 85 D1             STAZ  ACCUM
$1A5D A5 D2             LDAZ  ACCUH
$1A5F 69 00             ADCIM $00
$1A61 85 D2             STAZ  ACCUH
$1A63 D8                CLD
$1A64 68         EXIT   PLA
$1A65 A8                TAY
$1A66 68                PLA
$1A67 AA                TAX
$1A68 68                PLA
$1A69 40                RTI


ADDITIONAL ZERO PAGE LOCATIONS
ACCUL   $00D0
ACCUM   $00D1
ACCUH   $00D2
COUNT   $00D3
TIMEH   $00D4
TIMEL   $00D5
```

Table 1. The frequency counter program.

2

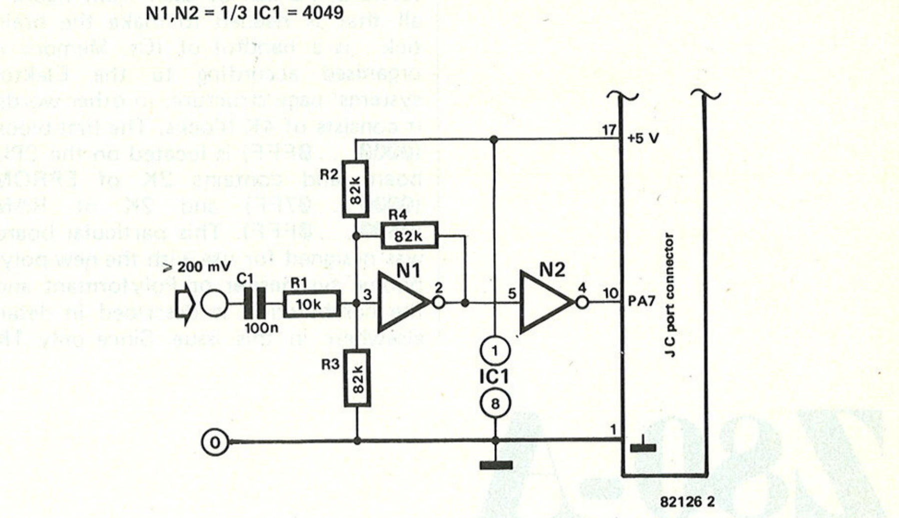


Figure 2. This circuit is added to the Junior Computer to effect the program in figure 1.

The events are depicted in the flow chart in figure 1.

A certain amount of hardware is also needed and this is shown in figure 2. This circuit is connected to the port connector of the Junior Computer to allow the frequency data to be entered into the computer. A significant negative zero-crossing in the input signal will pull port line PA7 low. The program makes sure this is accompanied by an IRQ.

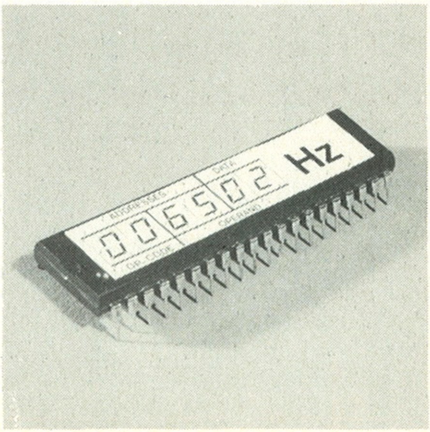
The software is provided in the table. The start address of the program is $1A00. When data is written into location EDETC, PA7 is pulled low thereby enabling an IRQ. Preparations include defining the IRQ jump vector at the start address of the IRQSRV interrupt routine, starting the interval timer (CNTH, in other words, an IRQ is enabled after every 1024 clock pulses) and storing the contents of location COUNT. Then the program LOOP is run until an IRQ takes place.

As soon as any type of IRQ is detected, the IRQSRV program is run. After saving the A, X and Y contents (used during SCANDS) on the stack, the computer examines the N flag. If N, or rather the timer flag, is zero, the IRQ cannot have been enabled by a time out. This means that it must have been caused by a change in logic level on PA7. A new AC voltage period has passed and so the computer proceeds to label ADD. The 24-bit BCD number (ACCUH, ACCUM, ACCUL — the period counter in figure 1) is incremented by one. After restoring A, X and Y (EXIT) and executing an RTI, the computer returns to LOOP.

Supposing the IRQ was caused by a time out in the interval timer. The timer is started afresh and the contents of COUNT are decremented by one. Provided COUNT has not yet reached zero, a jump will be made to EXIT. If, however, COUNT is in fact zero, the STORE section is run. The measuring period has now passed and the display buffers, POINTH, POINTL and INH, are assigned values equal to those of ACCUH, ACCUM and ACCUL, respectively.

So much for the program, let's put everything into practice. Connect the circuit in figure 2 to the port connector, enter the program on the keyboard (or even better, read it in from cassette) and start it via the main JC keyboard. (The main JC keyboard must be used, so as to provide the I/O definition for SCANDS.) The highest frequency that can be measured is about 10 kHz. At low frequencies greater accuracy may be obtained by extending the measuring time to 10 seconds (load A0 instead of 10 into TIMEH, address $1A16). The result on display will of course have to be divided by ten to give the correct frequency.

Literature:
Chapter 6 of the Junior Computer Book II.



Z80-A CPU card

. . . for the Polyformant

As the Z80 is still one of the most popular microprocessors around, it is high time the device was mentioned in Elektor. However, that is not the only motive behind this article, for the Z80-A CPU is the heart of the control circuitry for the new Elektor synthesiser. The board is compatible with the Elektor microprocessor bus system, so that the Eurocard collection will now be accessible to Z80 users.

U. Götz and R. Mester

Considering the amount of brain power stored away inside the Z80-A, the CPU card circuit is surprisingly straightforward. As can be seen from figure 1 all that is needed to make the brain tick is a handful of ICs. Memory is organised according to the Elektor systems' page structure, in other words, it consists of 4K blocks. The first block (0000 . . . 0FFF) is located on the CPU board and contains 2K of EPROM (0000 . . . 07FF) and 2K of RAM (0800 . . . 0FFF). This particular board was designed for use with the new polyphonic synthesiser or Polyformant and the combination is described in detail elsewhere in this issue. Since only 1K of RAM is required in this application IC18 and IC19 (see figure 1) may be omitted.

It is not absolutely necessary to position the memory ICs and their corresponding address decoders on the CPU board. Large amounts of software can best be stored on a separate (EP)ROM board, such as the Elektor RAM/EPROM card (ESS 80120). One or two minor modifications to the latter are required first, however, details of which are provided elsewhere in this issue.

Buffers

Any self-respecting CPU board will of course have to be properly buffered, as the CPU outputs are unable to drive a complete system directly. Since the buffers used here (IC9 . . . IC13) are tri-state and are enabled by the $\overline{BUSAK}$ signal, the DMA, or multiprocessing, facility of the Z80 is retained.

Speed

The processor is driven by a 4 MHz crystal oscillator. This is the highest possible clock frequency for a Z80-A or MK 3880-4 CPU. With the standard Z80 or MK 3880 the clock frequency should not exceed 2.5 MHz. It should be mentioned at this stage that the Polyformant requires a Z80-A (MK 3880 - 4) CPU.

Essentially, the operating speed of the processor mainly determines the time it takes to execute a program. In the Polyformant, the CPU must scan the keyboard and in the extended version it must also scan all the presets. Furthermore, it must pass on all the relevant data to the Polyformant modules (VCOs, VCFs and so on).

How much time these processes take depends on the response speed of the microcomputer. This is particularly important when the keyboard is being scanned. The faster the scan, the sooner a VCO will be able to react to a depressed key. Using the software package developed for the Polyformant, a VCO can respond within two or three milliseconds. This delay is far too short to be noticeable.

Wait cycles

The use of a high clock frequency automatically calls for corresponding processing speeds, or access times. The access time of a standard 2716 EPROM (IC15) will usually be too long for it to be addressed by the CPU. As for data entry, even less time is available for writing to the RAMs (IC16 . . . IC19)!

There are two ways in which this problem can be solved. The first method involves the use of high-speed memory devices, that is to say, EPROMs and RAMs with an access time of 350 ns and 250 ns, respectively. The latter are easily obtainable nowadays, but 350 ns EPROMs are a little harder to find. Strictly speaking, even 350 ns is 'cutting it a bit fine', although a shortcut may be taken by implementing the $\overline{OE}$ (output enable) input instead of the $\overline{CE}$ (chip enable) input. This enables a 350 ns 2716 to be used without the need for any special measures.

The other alternative is to slow down the CPU and use normal 'low-speed' EPROMs. This is done by adding wait cycles to read operations. A wait cycle lasts exactly one clock period, that is, 250 ns. The addition of a single wait cycle will therefore extend the EPROM access time to 500 ns, which gives plenty of leeway to even the most 'sluggish' types. The delay is effected by including flipflops FF1 and FF2 in the circuit.

The flipflops are only active while the EPROM (IC15) is being adressed (the D input of FF2 is low). They may be omitted if a 350 ns EPROM is available, in which case a wire link, J1 must be included instead of IC4. This deactivates the delay circuit. When testing the CPU, however, readers are advised to carry out the first method initially and include a wait cycle, so as to be absolutely sure that a slow EPROM will not complicate matters.

Any external memory or peripheral devices are also able to generate wait cycles by way of the $\overline{WAITEX}$ input.

1

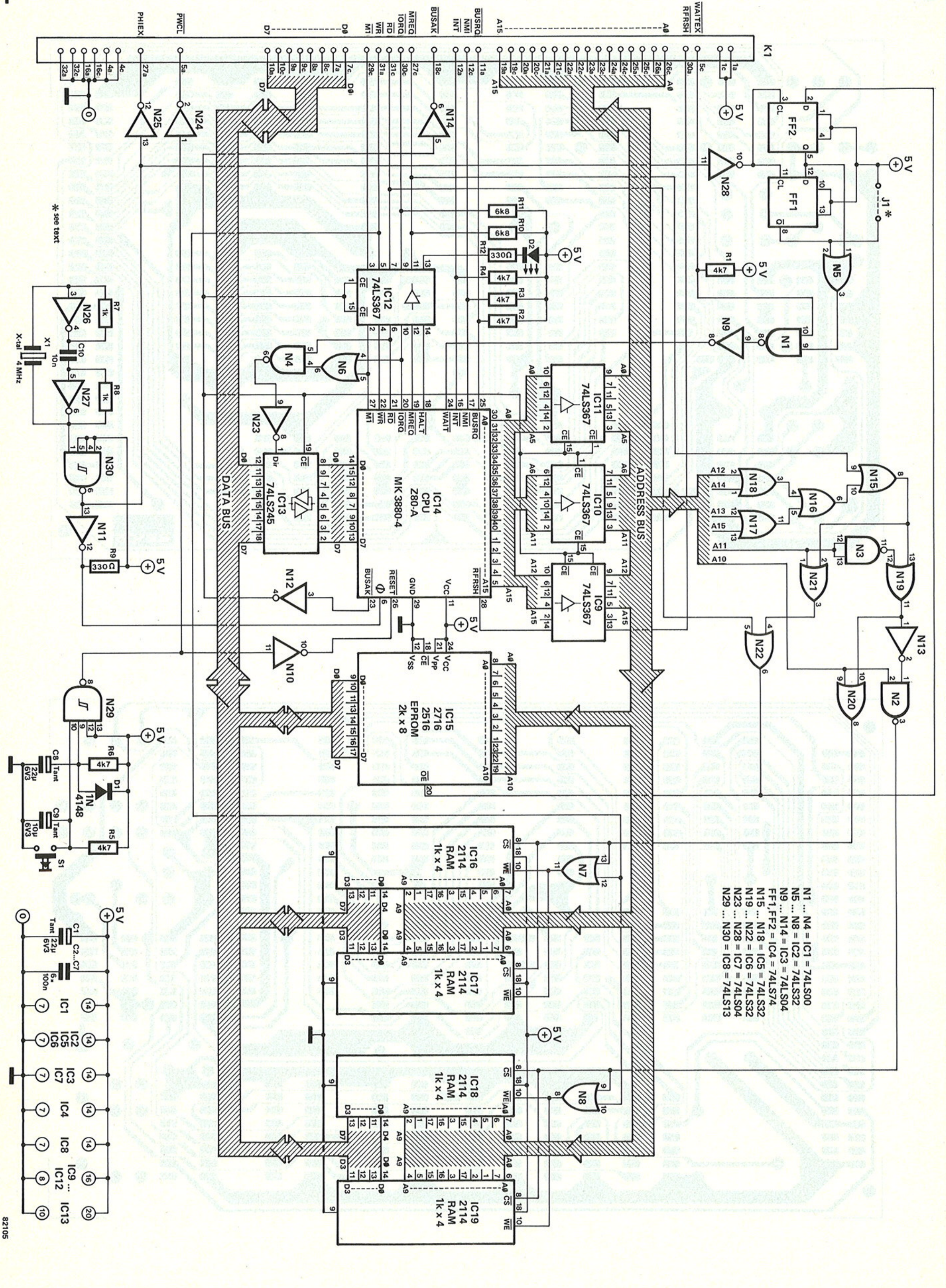


Figure 1. The circuit diagram of the Z80-A CPU card.

2

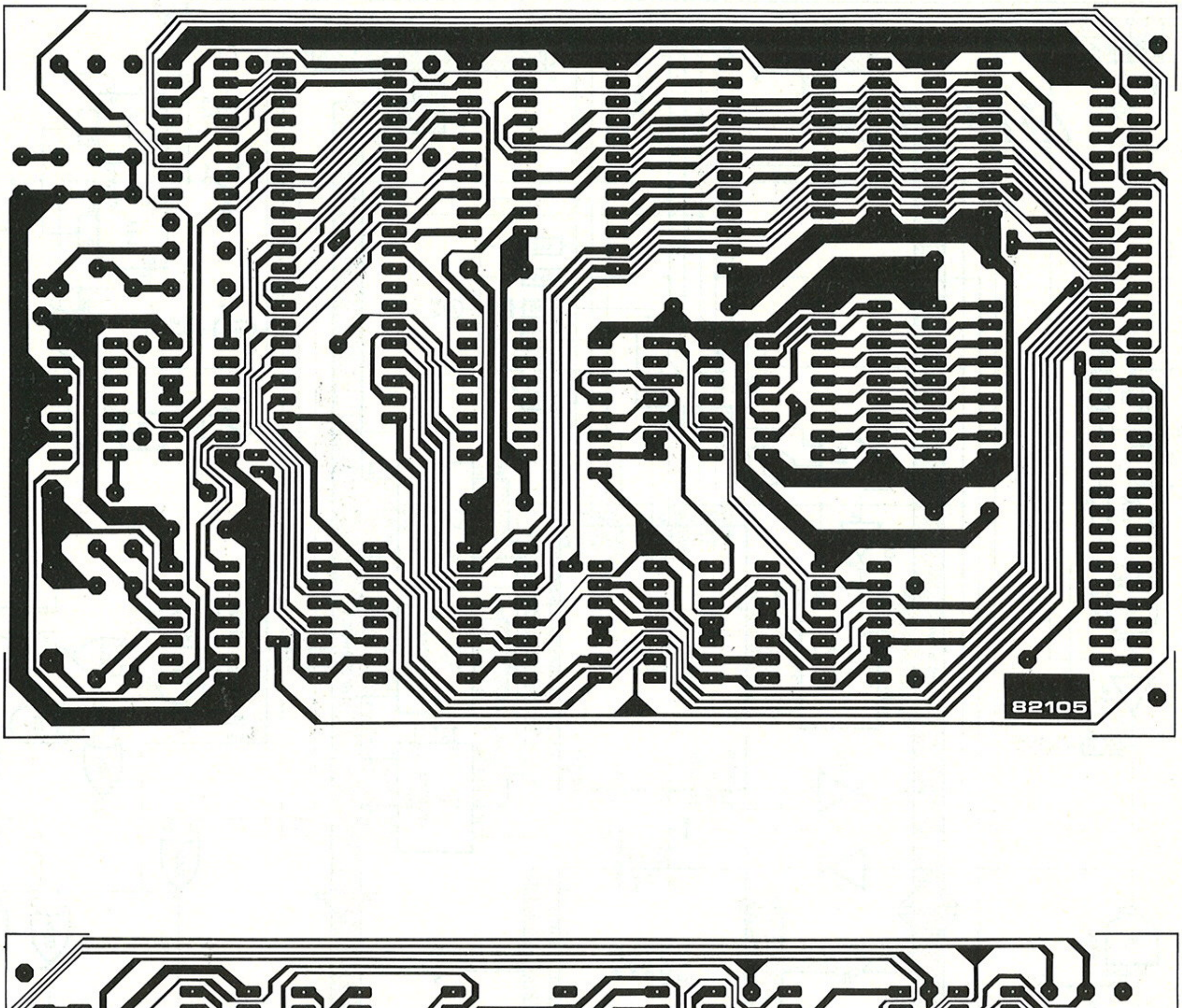


Figure 2. The copper track pattern for the double sided printed circuit board.

3

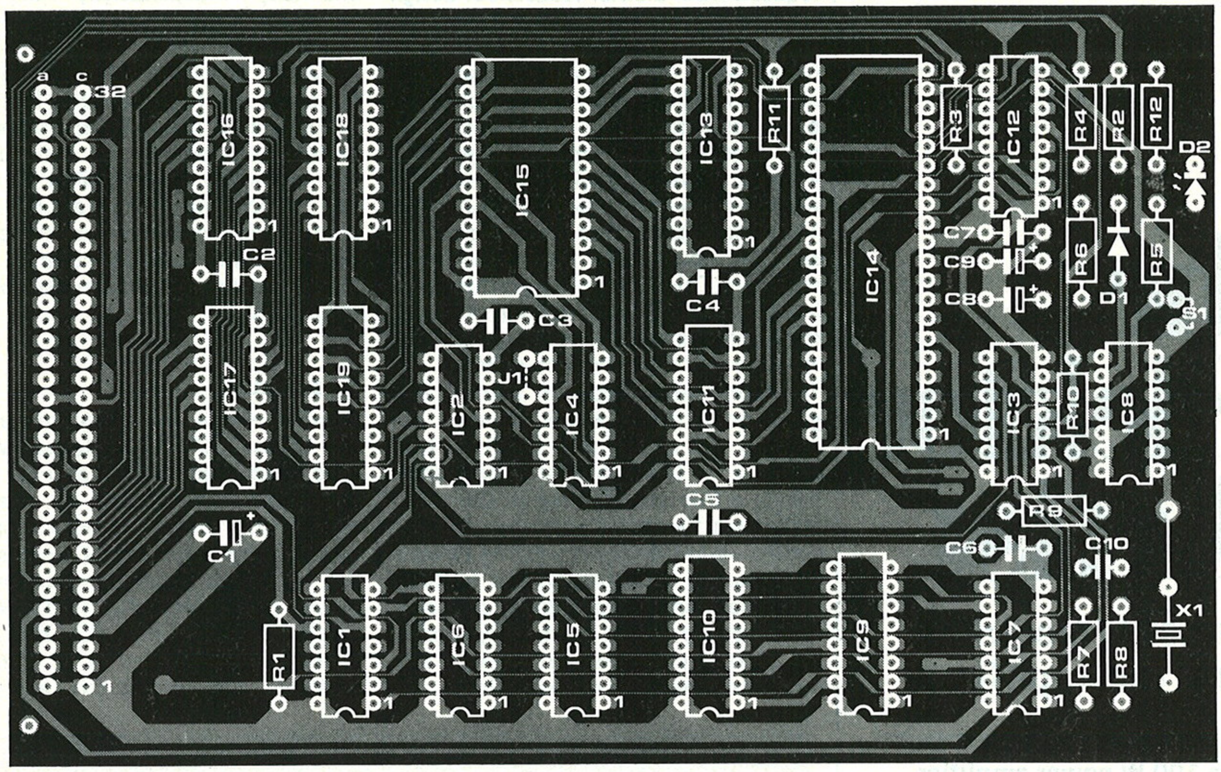


Figure 3. The component overlay for the Z80-A CPU card

Parts List

Resistors:
R1 . . . R6 = 4k7
R7,R8 = 1 k
R9 = 330 Ω
R10,R11 = 6k8
R12 = 470 Ω

Capacitors:
C1,C8 = 22 μ/6.3 V tantalum
C2 . . . C7 = 100 n ceramic or MKH
C9 = 10 μ/6.3 V tantalum
C10 = 10 n MKH

Semiconductors:
D1 = 1N4148
D2 = LED
IC1 = 74LS00
IC2,IC5,IC6 = 75LS32
IC3,IC7 = 74LS04
IC4 = 74LS74
IC8 = 74LS13
IC9 . . . IC12 = 74LS367
IC13 = 74LS245
IC14 = Z80-A (or MK 3880 - 4)
IC15 = 2716/2516
IC16 . . . IC19 = 2114-Z or 2114A-5
(access time 250 ns)

Miscellaneous:
S1 = push button switch
X1 = 4 MHz crystal
K1 = 64-pin connector

Reset

Reset circuitry is needed to initialise the CPU. When the power supply is switched on, R6, C8 and D1 hold the reset input of the CPU low for a while via N29 and N10. This is the $\overline{\text{PWCL}}$ signal and serves to reset any other boards connected to the system bus. An external reset facility has been provided for emergencies. It is advisable to place S1 'out of reach' to prevent it from being inadvertently depressed thus causing valuable information to be irrevocably lost.

The printed circuit board

Apart from S1, all the components in figure 1 are mounted on a Eurocard sized, double-sided, plated-through printed circuit board. This is shown in figure 2. As the pin assignment of the 64-pin connector corresponds to that of the Elektor bus system, the board may be used in combination with a number of existing cards.

The components should be mounted on the CPU card with due care, because in some places on the board the copper tracks are so close to each other that soldering may easily cause a 'short'. Although the board is provided with a solder mask to reduce this sort of problem, a great deal of care is still required.

Further information on the Z80

Enough has been written about the Z80 to fill an entire library. Plenty of software is available too, but users must be well-informed of the requirements of their particular system. Often the software has to be adapted for specific purposes and this does call for a fair amount of expertise. The CPU board published here was designed for the Polyformant and a special article is devoted to its use with the synthesiser. A brief description of the software is also given.

The Polyformant is, of course, just one application possibility out of thousands. The advantage of using the board in a different system is that the hardware can be adapted to existing software packages. Such modifications are usually left up to the user, but nine times out of ten it is much easier to rearrange computer circuitry than to rewrite programs.

Elsewhere in this issue an article describes how to modify the 8K RAM + 8K EPROM card for use with the Z80 and therefore how readers can create their 'own' computer system.

the Elektor Artist

a versatile electric guitar preamplifier

This preamplifier is a companion to the 100 W power amplifier published in the April 1982 issue of Elektor. Two independent channels are provided each with two inputs. Features include high and low impedance inputs, extensive tone controls, built-in reverb and fuzz and effect 'loop' switching, providing the musician with all the extras normally found on the more expensive equipment at a reasonable price. Although originally designed for the guitarist, it can of course, be used with any other electronic instrument such as an organ or synthesiser.

Designing a really good circuit for a guitar preamplifier was quite a challenge. After a considerable number of requests from Elektor readers our design staff set about creating the Artist. The primary objective was to produce a preamplifier that satisfied a discerning musician while still remaining a practical proposition for home construction. All the Artist's effects are combined onto a single printed circuit board, thereby simplifying construction considerably. The advantages of the switching modes will be obvious to the adventurous musician. This facility is something that musicians are always looking for, but rarely finding in commercial equipment, with the possible exception of HH.

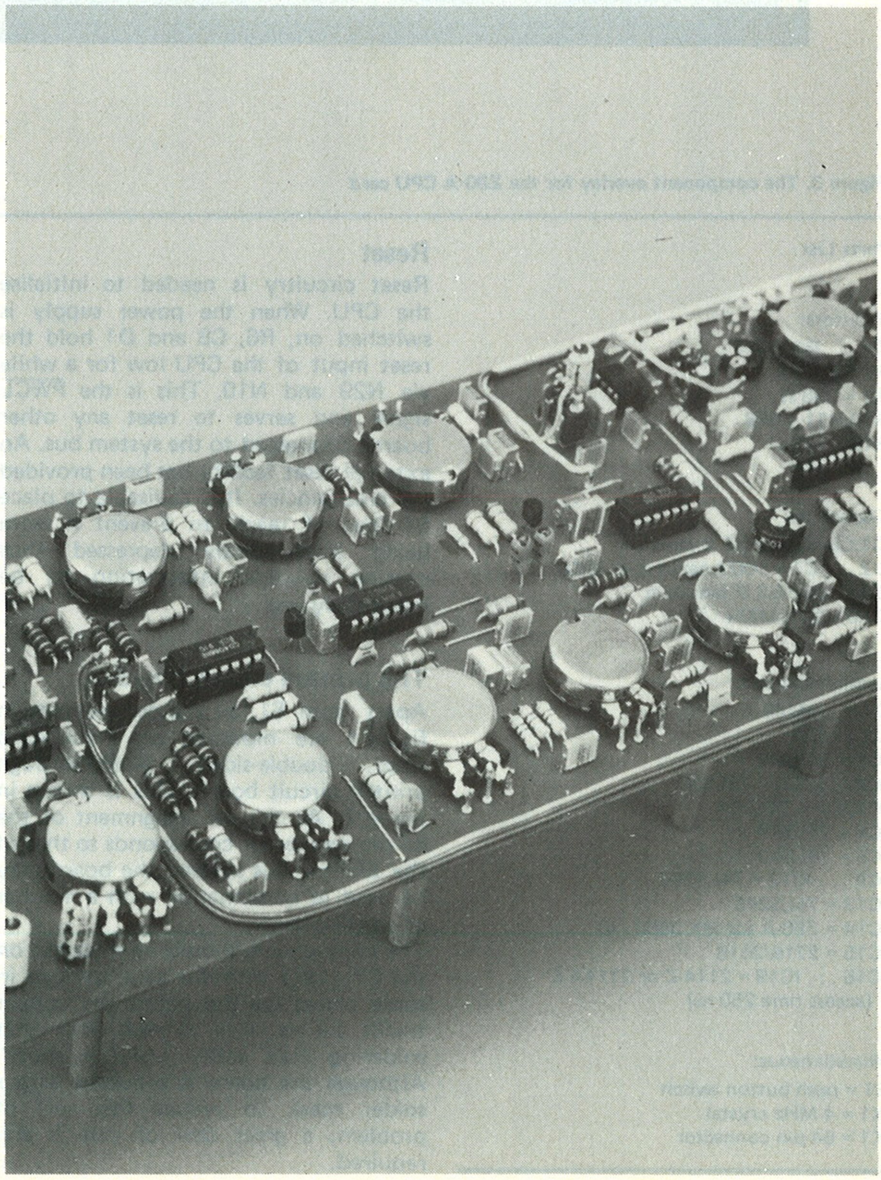
The front panel layout in figure 4 is a good point from which to start describing the circuit and facilities. It is basically a twin channel preamplifier having a low and high input. Channel I includes a five band graphic type tone control circuit, built-in Fuzz and Reverb. The amount of distortion can be fully controlled and ranges from a 'clean' to extremely 'dirty' sound. By-passing the Fuzz circuit does not result in any noticeable change in output volume. Channel II has a simpler parametric type of tone control and reverb. The reverb 'loop' can be patched into both channels, independently or simultaneously. The Fuzz circuit is only available on channel I.

A switch enables an input to be fed to either of the two channels. This allows the player to preset both channels and switch from one to the other at will. The channel change facility as well as the 'effect' switching can be remote controlled by means of foot switches.

Finally, input volume controls and a master volume potentiometer complete the circuit.

The circuit

Figure 1 shows the circuit diagram of the 'Artist'. CMOS analogue switches have been used instead of FET power transistors. This helps to keep the overall cost down without impairing quality. The input signal from sockets Ba5 . . . Ba8 is fed to the non-inverting inputs of A1 and A3 (IC1), via the resistor network R1, R2, R39, R40. These set the sensitivity of the input (tailoring it to any guitar), and ensure



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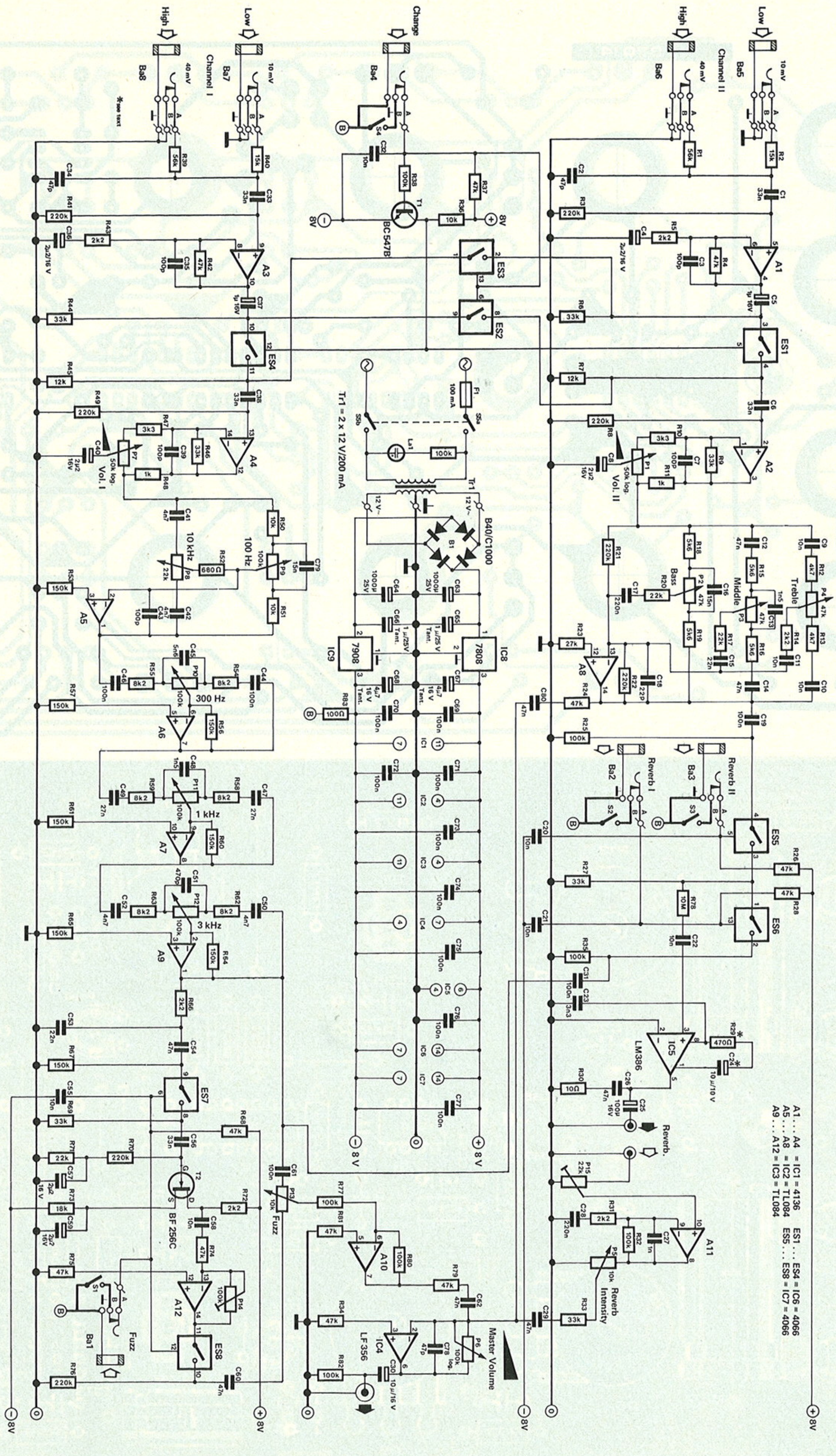
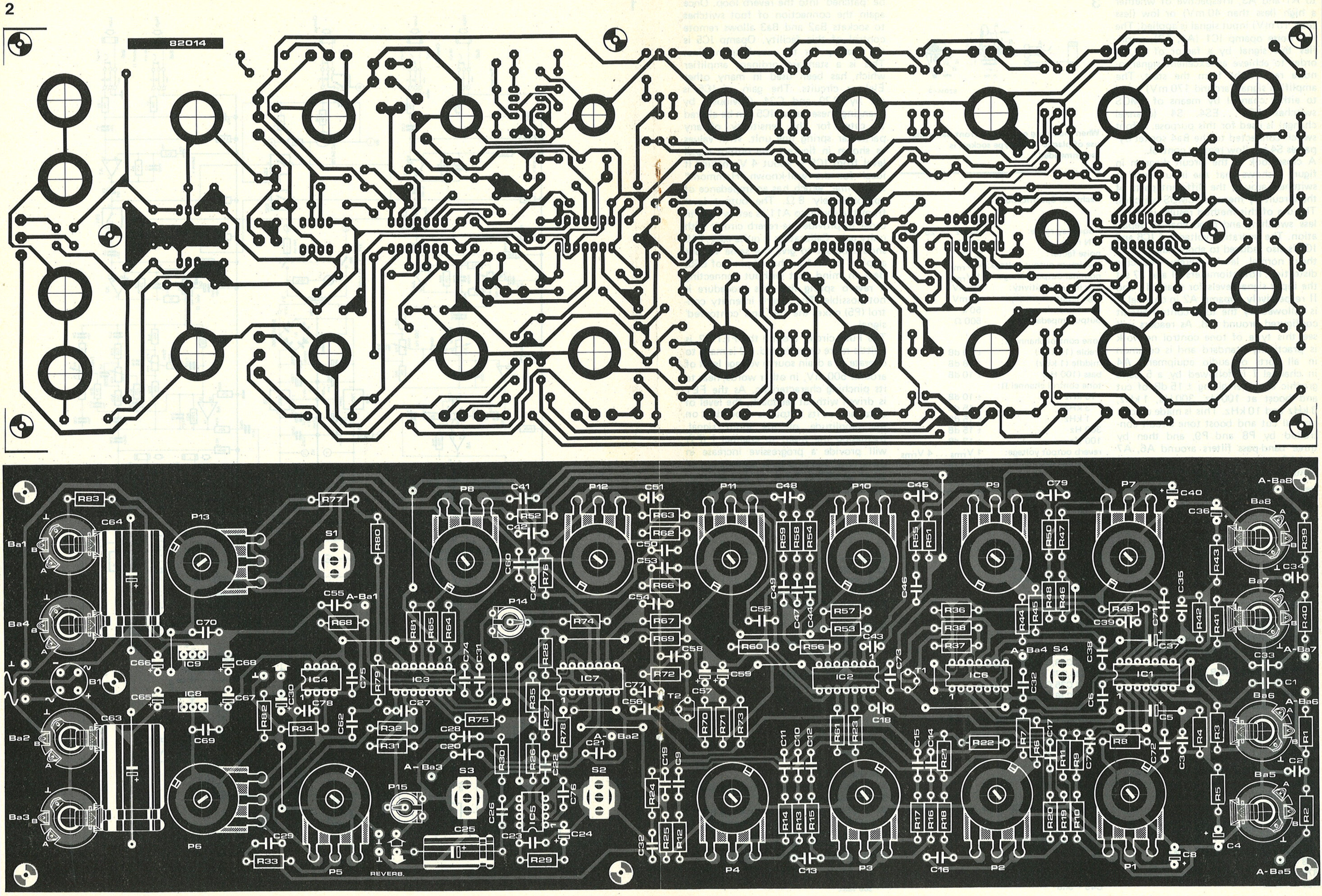

High
Low
Channel I
Ba8
Ba7
40 mV
10 mV
* see text
Change
Ba4
T1
BC547B
High
Low
Channel II
Ba6
Ba5
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
ES1
ES2
ES3
ES4
ES5
ES6
ES7
ES8
Vol. I
Vol. II
10 kHz
100 Hz
300 Hz
1 kHz
3 kHz
Bass
Middle
Treble
Tr1 = 2 x 12 V/200 mA
B40/C1000
7808
7908
IC8
IC9
Reverb I
Reverb II
Ba2
Ba3
LM386
IC5
Reverb
Reverb Intensity
Master Volume
LF356
IC4
BF 256C
T2
Fuzz
Ba1
82014-1
A1 . . . A4 = IC1 = 4136   ES1 . . . ES4 = IC6 = 4066
A5 . . . A8 = IC2 = TL084   ES5 . . . ES8 = IC7 = 4066
A9 . . . A12 = IC3 = TL084
+8V
-8V
0

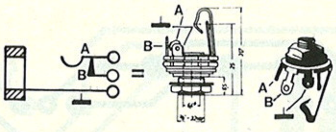
2


82014
R83
R77
C64
P13
S1
R80
P8
C41
P12
C51
P11
C48
P10
C45
P9
C79
P7
C40
A-Ba8
Ba8
C36
R39
R52
C42
R63
R62
C50
C53
R66
C54
R67
R69
C58
R72
C59
C60
R76
C61
R59
R58
R54
R55
R51
R50
R47
R43
C34
Ba7
C35
Ba1
Ba4
Ba2
Ba3
Ba5
Ba6
Ba7
A-Ba1
C55
R68
C70
IC9
IC8
C66
C68
C65
C67
B1
C63
C69
R81
R65
R64
C74
C31
P14
R74
R28
IC7
IC4
IC3
IC2
IC6
IC1
IC5
C75
C30
R79
C78
C27
C62
R82
R34
R32
R31
R75
C28
C20
R35
R27
R26
R30
R78
C21
A-Ba2
A-Ba3
A-Ba4
A-Ba5
A-Ba6
A-Ba7
C77
C56
T2
T1
C57
R70
R71
R73
C18
R61
R23
R22
R7
R6
R8
C17
R11
R9
C7
C72
C3
R4
R3
R1
C2
R5
R2
C4
C8
R57
R53
C43
R60
R56
C52
C49
C47
C44
C46
C73
R36
R38
R37
S4
C38
C32
C6
R44
R45
R48
R46
R49
C39
C71
C37
R42
R41
R40
C33
C1
C5
C26
C76
S2
S3
P15
C25
C23
C24
R29
C29
R33
P6
P5
P4
P3
P2
P1
C19
C9
R24
R25
R12
C11
C10
C12
C15
C14
R21
R14
R13
R15
R17
R16
R18
R20
R19
R10
C13
C16
C22
REVERB.

that an input level of 7.5 mV is available to A1 and A3, irrespective of whether a high (less than 40 mV) or low (less than 10 mV) input signal is applied. The low noise opamp IC1 (A1, A3), amplifies this signal by a factor of 22, in order to achieve an excellent signal-to-noise ratio right from the start. The amplified signal (around 170 mV) is fed to either channel by means of CMOS switches ES1 . . . ES4. S4 (channel change) is used for this purpose. A foot switch connected to the Ba4 socket bypasses S4 to allow remote control.

A close look at the circuit diagram in figure 1 shows that the input signal is switched around the different parts of the circuit by means of CMOS switches. The use of this method results in noiseless switching and good channel separation. The operating voltage of IC6 and IC7 is also reduced to about half (± 8 V) their normal level, thereby reducing distortion. Potentiometers P1 and P7 set the input signal levels for channel I and II respectively. Opamp A2 in channel II is followed by the tone control circuit configured around A8. As readers will see this type of tone control network is practically standard and is common in all sorts of audio equipment. A4 in channel I is followed by a 5 band graphic equaliser giving ± 15 dB of cut and boost at 100 Hz, 300 Hz, 1 kHz, 3 kHz and 10 kHz. This is made up of a normal cut and boost tone circuit controlled by P8 and P9, and then by three band-pass filters around A6, A7 and A8.

3



When mounting onto metal front panel the use of plastic collar type sockets is recommended.

Technical Specifications

frequency range:	40 Hz . . . 25 kHz
S/N ratio:	60 dB
noise factor:	0.1%
maximum output voltage:	4 V_{rms}
nominal output voltage:	1 V_{rms}
low input sensitivity:	10 mV
high input sensitivity:	40 mV
input impedance:	50 k
output impedance:	500 Ω
tone control channel I:	
treble (10 kHz)	± 10 dB
middle (1 kHz)	± 8 dB
bass (100 Hz)	± 10 dB
tone control channel II:	
10 kHz	± 10 dB
3 kHz	± 15 dB
1 kHz	± 15 dB
300 Hz	± 15 dB
100 Hz	± 12 dB
reverb output voltage:	1 V_{rms} . . . 4 V_{rms}
fuzz threshold:	1.5 V_{rms}

Switches S2 and S3 control ES5 and ES6 allowing either, or both channels to be 'patched' into the reverb loop. Once again the connection of foot switches to sockets Ba2 and Ba3 allows remote control of this facility. Opamp IC5 is the preamp for the reverb spring line. This is a standard ordinary amplifier which has been used in many other Elektor circuits. The gain of IC5 is set by R29 and C24. Obviously by changing these values IC5 can be altered to cater for the sensitivity of any particular spring line unit. With values as shown in figure 1 the output signal level from IC5 is about 4 V, making it ideal for the well-known 'Hammond' spring line, which has an impedance of approximately 8 Ω. The output level from the spring to A11, is set by P15, in order to provide the reverb circuit with unity gain. Calibration is quite easy, P15 should be set to give the same voltage at pin 8 of A11 as that of pin 3 of ES5. Bear in mind that without connecting a reverb spring line this procedure is not possible. The reverb intensity control (P5) mixes the 'flat' and 'contoured' signal.

The Fuzz circuit around the FET T2, is a little more complicated. T2 is made to operate at a drain source voltage level of around 500 mV, in other words, near to its pinching characteristic. As the FET is driven without feedback, the level of distortion at its output is dependent on the amplitude of the input signal. Increasing the input to channel I (P7) will provide a progressive increase in distortion, giving a tone reminiscent of valve amplifiers. Just as a matter of

Parts list

Resistors:
R1,R39 = 56 k
R2,R40 = 15 k
R3,R8,R21,R22,R41,R49,R70,R76 = 220 k
R4,R24,R26,R28,R34,R37,R42,R68,R74, R75,R79,R81 = 47 k
R5,R14,R31,R43,R66,R72 = 2k2
R6,R9,R27,R33,R44,R46,R69 = 33 k
R7,R45 = 12 k
R10,R47 = 3k3
R11,R48 = 1 k
R12,R13 = 4k7
R15,R16,R18,R19 = 5k6
R17,R20,R71 = 22 k
R23 = 27 k
R25,R32,R35,R38,R77,R80,R82 = 100 k
R29* = 470 Ω
R30 = 10 Ω
R36,R50,R51 = 10 k
R52 = 680 Ω
R53,R56,R57,R60,R61,R64,R65, R67 = 150 k
R54,R55,R58,R59,R62,R63 = 8k2
R73 = 18 k
R78 = 10 M
R83 = 100 Ω

P1,P7 = 47 k logarithmic
P2,P3,P4 = 47 k linear
P5,P13 = 10 k linear
P6 = 100 k log.
P8 = 22 k linear
P9,P10,P11,P12 = 100 k linear
P14 = 100 k preset
P15 = 22 k preset

Capacitors:
C1,C6,C33,C38,C56 = 33 n
C2,C34,C78 = 47 p
C3,C7,C35,C39,C43 = 100 p
C4,C8,C36,C40,C57,C59 = 2µ2/16 V
C5,C37 = 1 µ/16 V
C9,C10,C11,C20,C21,C22,C32,C55, C58 = 10 n
C12,C14,C26,C29,C32,C54,C60,C62 = 47 n
C13,C48 = 1n5
C15,C53 = 22 n
C16,C79 = 15 n
C17,C28 = 220 n
C18 = 22 p
C19,C31,C44,C46,C61,C69 . . . C77 = 100 n
C23 = 3n3
C24* = 10 µ/10 V tantalum
C25 = 100 µ/16 V
C27 = 1 n
C30 = 10 µ/16 V
C41,C42,C50,C52 = 4n7
C45 = 5n6
C47,C49 = 27 n
C51 = 470 p
C63,C64 = 1000 µ/25 V
C65,C66 = 1 µ/25 V tantalum
C67,C68 = 4µ7/16 V tantalum

Semiconductors:
B1 = B40C1000 bridge rectifier (round version)
T1 = BC 547B
T2 = BF 256C, BF 245C
IC1 = XR 4136, RC 4136
IC2,IC3 = TL 074, TL 084
IC4 = LF 355, LF 356
IC5 = LM 386
IC6,IC7 = 4066
IC8 = 7808
IC9 = 7908

Miscellaneous:
S1 . . . S4 = sp on/off switch (for single hole)
S5 = dp mains switch
Ba1 . . . Ba8 = ¼ in mono jack with switch
Tr1 = 2 x 12 V/200 mA mains transformer
La1 = mains LED indicator
F1 = 100 mA MT fuse with fuse holder
reverb spring line (Watford Electronics)

* = see text

4

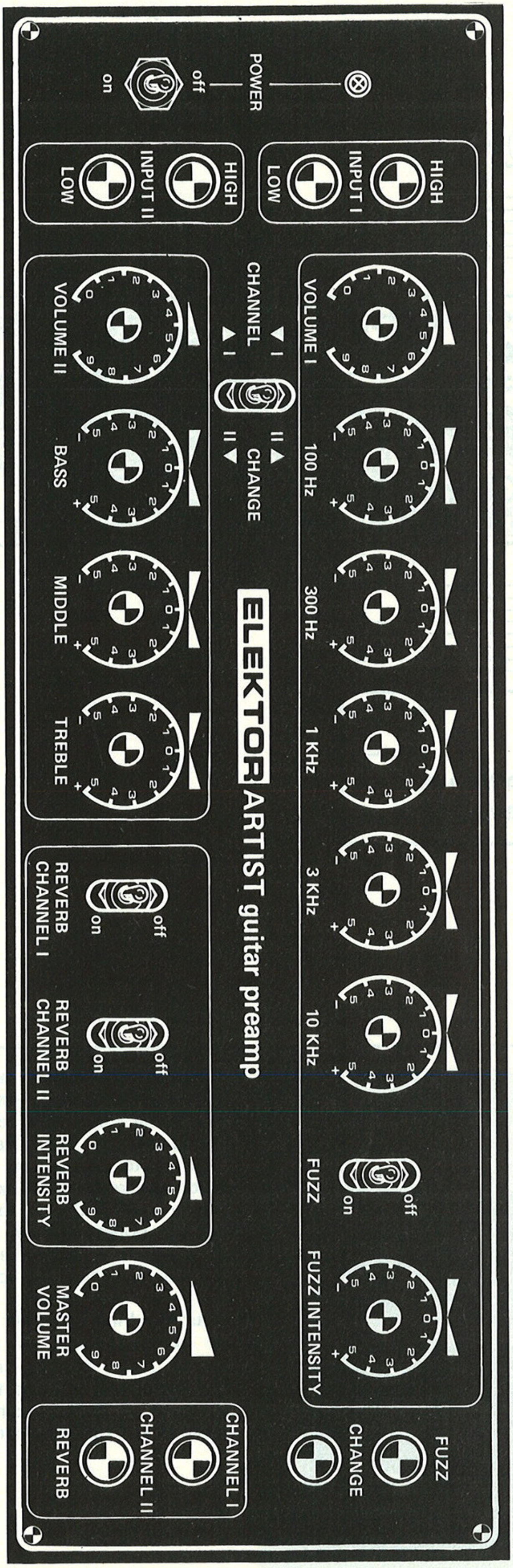


Figure 4. A suitable front panel layout.

interest, an input signal of 1.5 V would completely overdrive the FET and 'clipping' would result, just like any normal harmonic generator. As with the reverb circuit, P13 (Fuzz intensity) mixes the flat and distorted signals. The Fuzz 'loop' circuit has unity gain (set by P14), in other words, no change in volume when the Fuzz is by-passed.

Finally all the channel and effects 'loop' signals are mixed into the output stage (IC4) by way of the summing resistors R24, R33, R79, and the capacitors C29, C32, C62. The (master volume) P6 controls the overall output level.

The symmetrical power supply circuit uses two voltage regulators IC8 and IC9.

Setting up

This merely involves the setting of the two presets P14 and P15, which is easily done by using a multimeter set to 5 V AC. Calibration is not critical, an accuracy of ± 5% is sufficient.

A nominal signal is fed to one of the inputs of channel I (10 mV low, 40 mV high). If your signal generator is not provided with a meter, measure the voltage at pin 10 of A3 (IC1), and divide by 20. This will give a good indication of the input voltage level. Now set the wipers of all the equalisation potentiometers to their centre point. Rotate P7 until 1 V is measured at pin 1 of A9 (IC3). P15 is also set to give a reading of 1 V at pin 8 of A11 (IC2). The same procedure is repeated for channel II (do not forget to connect the reverb spring line), only this time P14 is turned up until 1 V is at pin 14 of A12 (IC3).

The printed circuit board

Almost all the electronic components and hardware are mounted on one single board, making construction simple and straightforward. The lack of normal wiring helps to keep noise and the possibility of mistakes down to a minimum. Even the wiring to the switches/sockets should present no problem as they only conduct DC voltages.

For the sake of economy no provision has been made for the mounting of the mains transformer and spring line onto the printed circuit board. Even so, readers will find no difficulties in connecting them up. Screened cable should be used for this purpose.

Construction

Standard (¼ ins) mono jack sockets are used throughout mounted directly onto the front panel. Keep the connection wires as short as possible and use the plastic collar type of jack sockets, in order to avoid earth loops. A suitable front panel design is shown in figure 2. When using a metal front panel, care should be taken to ensure that none of the potentiometer spindles, toggle switches come into contact with it,

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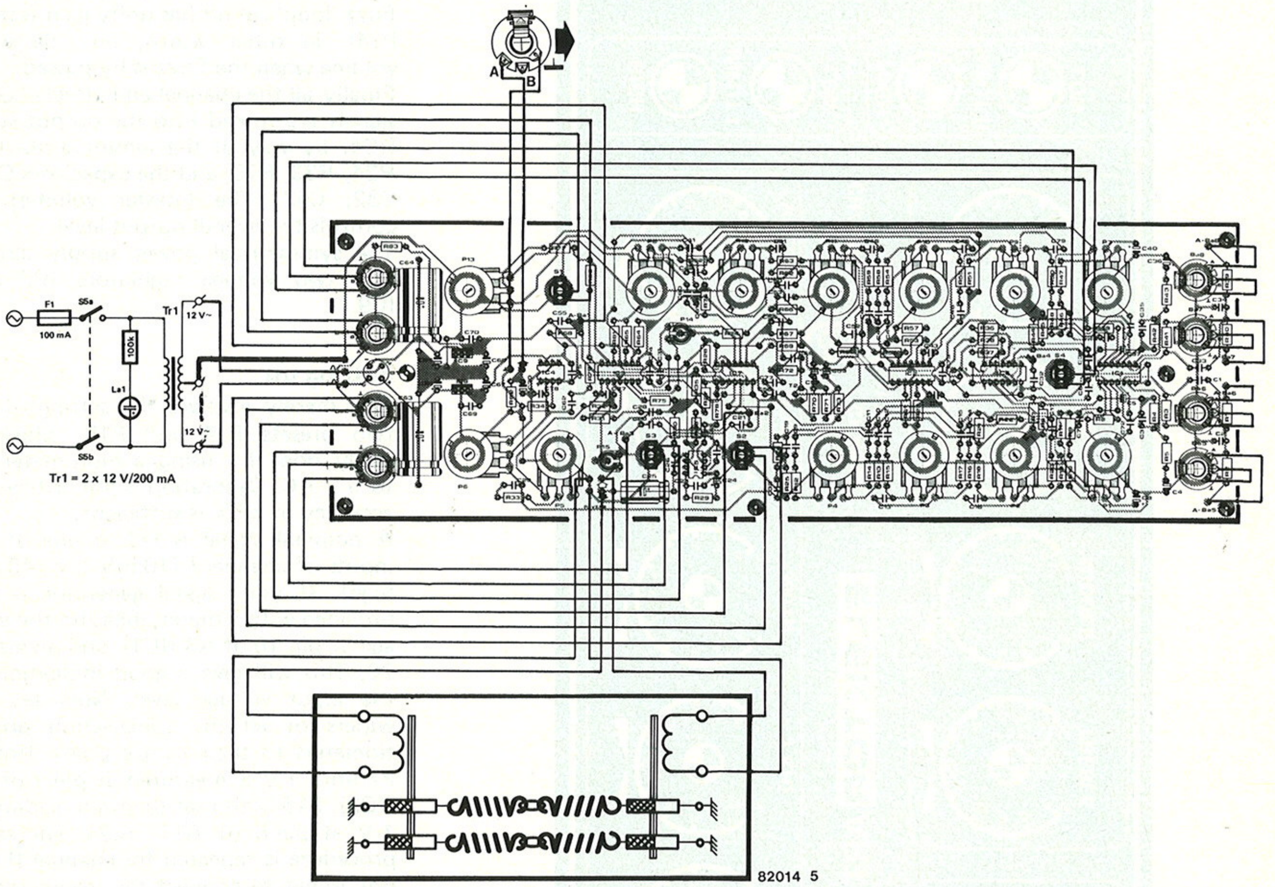
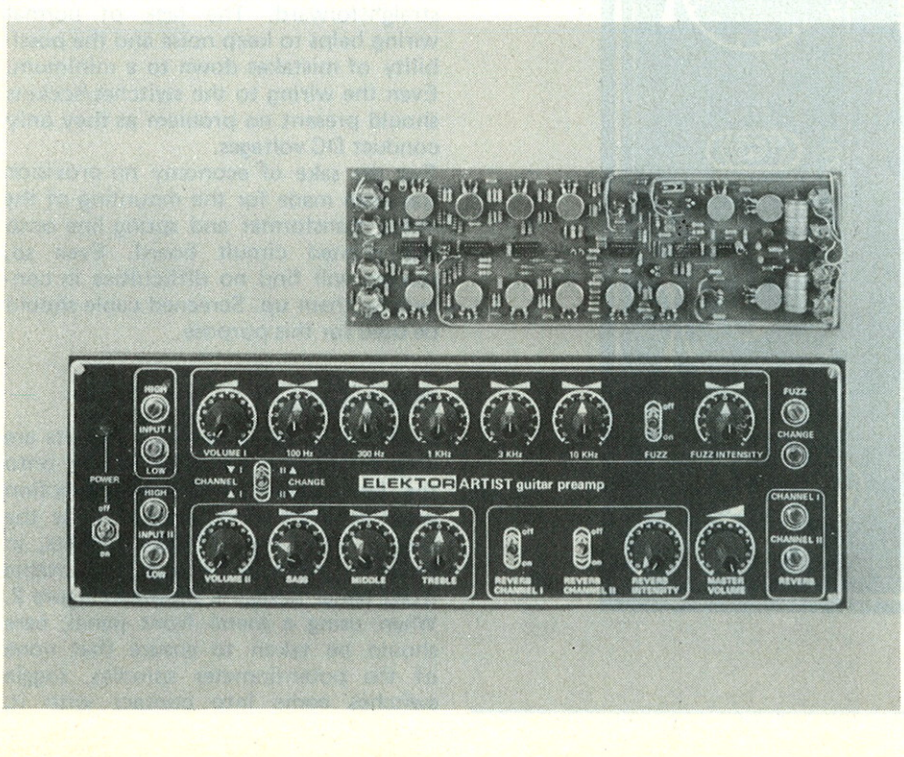


Figure 5. This clearly shows all connections to the p.c. board.



otherwise unnecessary noise is generated. This is specially important when considering the sockets, since the ground of the input has a different potential to the ground of the footswitch sockets. One good idea (as already adviced) is to use plastic spindled potentiometers and insulated sockets. It is left to the reader to decide whether to leave the sockets on the board or not. Finally don't forget about the kind of power amplifier you are going to use. In principle, the Elektor Artist can be used with any. But please, bear in mind that it will not overcome all the shortcomings of some amplifier and speaker systems around.

prop tachometer

a rev counter for model aeroplanes

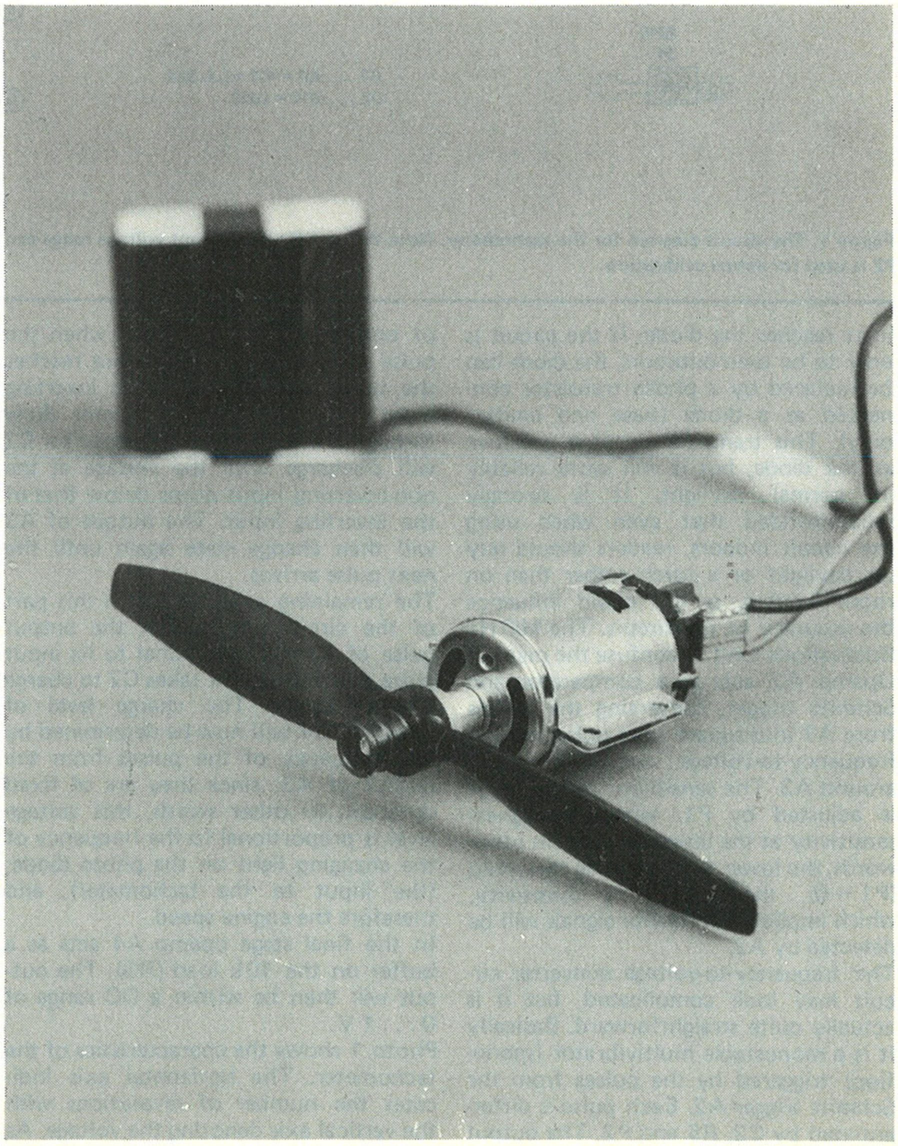
Modellers tend to be rather slow in getting into electronics. This could stem from the fact that balsa wood and electronics are quite a few worlds apart, so that modellers may question their own skill with a soldering iron. Expertise and reliability are certainly important factors where model aircraft are concerned, as any errors are inevitably costly. However, for certain applications, like the one described here, the simplicity of construction together with the help of a ready made printed circuit board, achieves a high reliability factor.

As aeromodellers will know, it is necessary to match a particular propeller with any given engine. Each propeller has a specification, indicating the optimum efficiency relative to its 'speed' (rpm). Therefore a way of measuring its speed is essential. When an engine is being tuned it is also very useful to be able to check the rpm relative to any adjustment made. A mechanical method would prove costly and rather complicated to make. The only sure way to achieve a high standard with a relatively low cost is to use an electronic circuit. The speed of the propeller can be determined with the aid of opto-electronics. An analogue indication can be provided by means of a moving coil meter or, if digital is preferred, by using a digital display. Which method used will determine the cost.

The circuit

The most straightforward part of the circuit is the power supply. For convenience and mobility a 9 V battery is utilised. The power consumption is surprisingly low.

The signal from the photo diode or -transistor D1, is amplified by opamp A1. With the turning 'prop' in front of the diode the amount of light falling on D1 will be fluctuating in direct proportion to the speed of the engine. It is advisable to place a dark-coloured 'prop' against a light background and a light 'prop' against a dark background. Diodes are included in the feedback loop of A1 to ensure that its gain will be logarithmic to compensate for changes in ambient light levels. R1 is also included to stabilise A1 when very little



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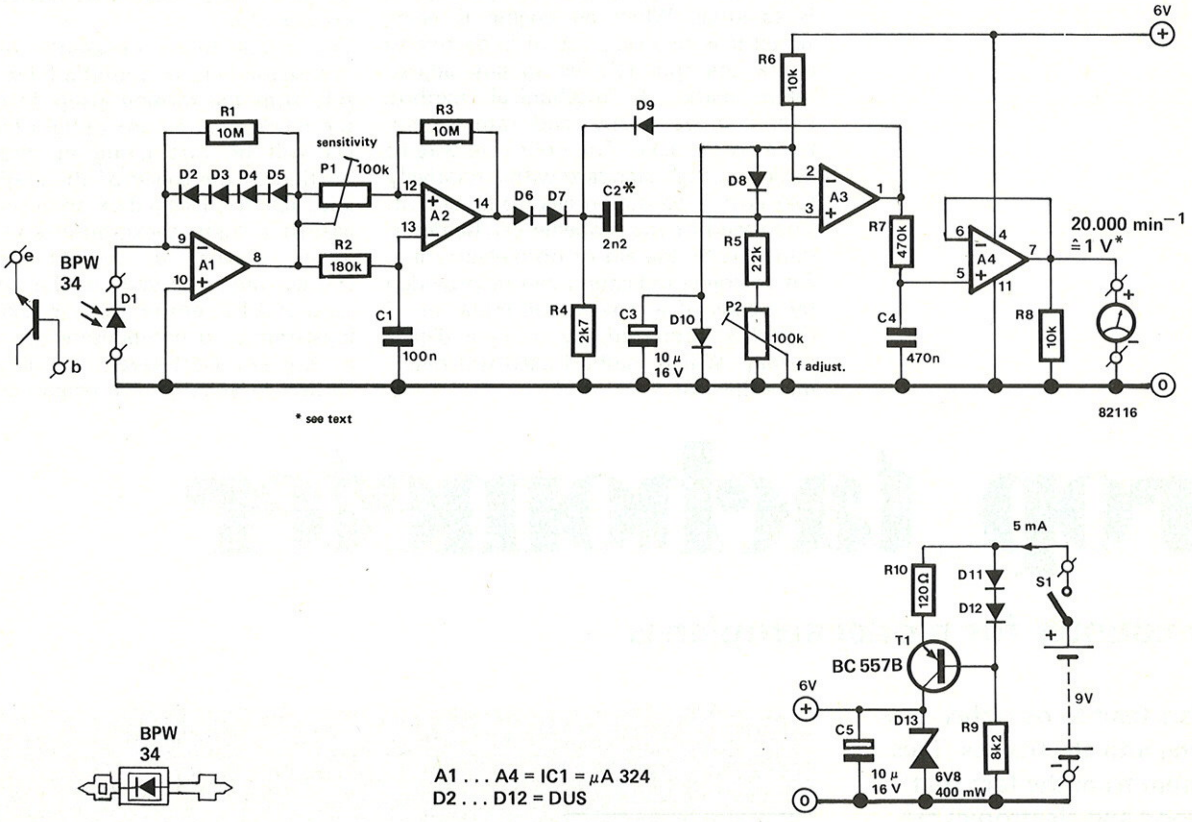


Figure 1. The circuit diagram for the tachometer. Note that a different output voltage range can be obtained by selecting a different value for C2; P2 is used for actual calibration.

light reaches the diode. If the circuit is only to be used outdoors, the diode can be replaced by a photo transistor connected as a diode (base and emitter only). This transistor is not as sensitive as the diode, but it will work reliably in normal daylight. It is strongly recommended that even when using the circuit indoors, readers should rely on daylight or a torch rather than on room lighting, as this could influence the accuracy of the circuit. The 100 Hz fluctuations tend to confuse the meter.

Opamp A2 acts as a comparator and Schmitt trigger, converting the signals from A1 into square wave pulses for the frequency-to-voltage converter circuit around A3. The sensitivity of this stage is adjusted by P1, with the highest sensitivity at the lowest setting. In other words, the lower the switching threshold (P1 → 0), the higher the sensitivity, which implies that smaller signals will be detected by A2.

The frequency-to-voltage converter circuit may look complicated, but it is actually quite straightforward. Basically it is a monostable multivibrator (monoflop) triggered by the pulses from the Schmitt trigger A2. Each pulse is differentiated by C2, R5 and P2. The output of opamp A3 will go 'high' when the pulse at its non-inverting input reaches the same value as that of its inverting input, thus causing a current flow through D9. Consequently capacitor C2 will discharge until the voltage at the non-inverting input drops below that of the inverting input. The output of A3 will then change state again until the next pulse arrives.

The remaining components in this part of the circuit ensure that the output pulse of A3 is proportional to its input pulse and the time it takes C2 to charge and discharge. The charge level of capacitor C4 will now be determined by the frequency of the pulses from the output of A3, since they are of fixed duration. In other words, this voltage level is proportional to the frequency of the changing light on the photo diode, (the input to the tachometer), and therefore the engine speed.

In the final stage opamp A4 acts as a buffer on the 10 k load (R8). The output will then be within a DC range of 0 . . . 1 V.

Photo 1 shows the characteristics of the tachometer. The horizontal axis indicates the number of revolutions with the vertical axis denoting the voltage. As can be seen, a good linear relationship exists between the two.

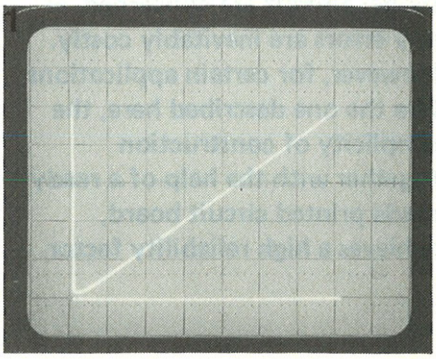


Photo 1. The output characteristic of the tachometer. The horizontal scale is 100 Hz (300 rpm) per division; the vertical is 200 mV/div.

Practical hints

Figure 2 shows the track layout for the printed circuit board. The battery can be attached to the board, if desired, by means of double-sided adhesive tape.

It is strongly advised that the photo transistor (or diode) is mounted in some

2

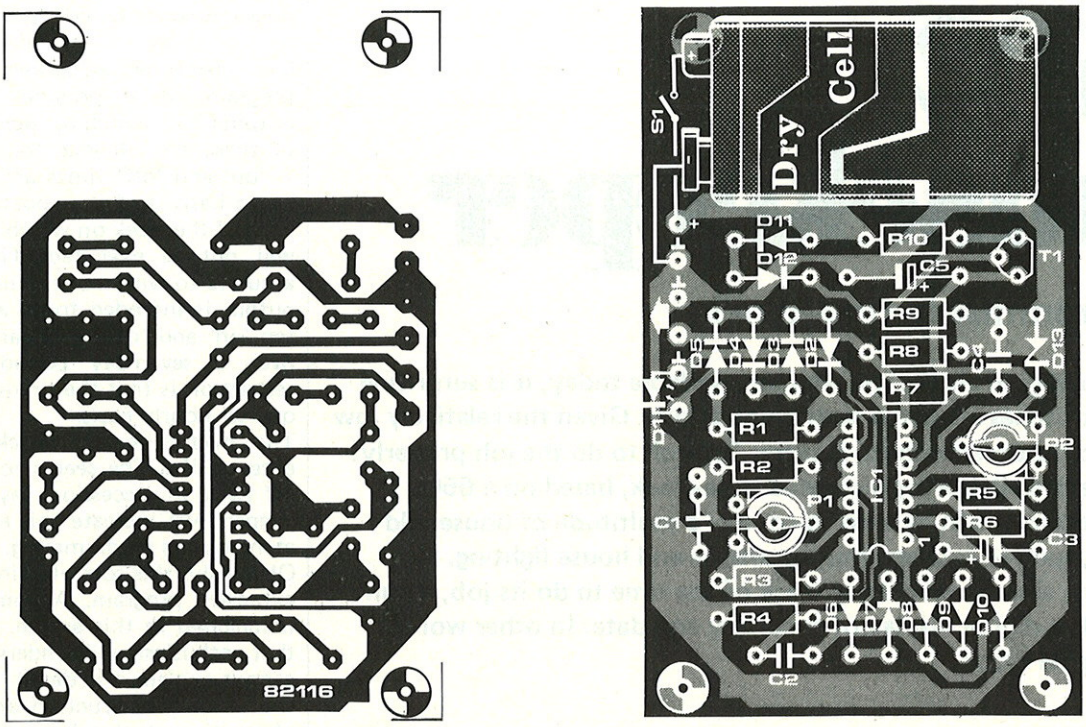


Figure 2. The track pattern and component overlay of the printed circuit board for the prop tachometer. The board has been designed to fit in a plastic case from Vero (202-21029J) or West Hyde (BOC 430). Since consumption is very low the battery will last quite a long while. In this case, it may be advisable to secure it with a piece of double-sided sticky tape.

Parts list

Resistors:
R1,R3 = 10 M
R2 = 180 k
R4 = 2k7
R5 = 22 k
R6,R8 = 10 k
R7 = 470 k
R9 = 8k2
R10 = 120 Ω
P1,P2 = 100 k presets

Capacitors:
C1 = 100 n
C2 = 2n2*
C3,C5 = 10 μ/16 V
C4 = 470 n

* see text

Semiconductors:
D1 = BPW 34 (Electrovalue) or
phototransistor
D2 . . . D12 = DUS
D13 = BZY 6V8 400 mW
T1 = BC 557B
IC1 = LM 324

Miscellaneous:
S1 = single pole on/off switch
9 V battery

form of protective 'handle' since it is known that fingers coming into contact with a prop turning at 15,000 rpm cause a sharp decrease in interest in all things concerned with aero modelling. Keep the connection wires between the diode and the circuit as short as possible.

Calibration

Setting up the circuit is very straightforward requiring the adjustment of only one potentiometer (P2). Connect a multimeter to the output, switch the circuit on and measure the offset voltage. Take careful note of this reading as it will be required later.

A normal fluorescent light tube can now be used as a calibration source. This is ideal because the light output varies in a 100 Hz rhythm (twice the mains frequency). This is equivalent to 6000 pulses-per-minute, or 3000 revs of a normal twin-blade propellor! Point the photo-diode at the lamp and adjust potentiometer P2 to give a reading on the multimeter of 150 mV DC plus the offset voltage, (the previously obtained reading). That's it, as far as calibration is concerned. The sensitivity is adjusted by means of P1, when measuring the revs of a propeller. Obviously this setting will depend on the distance between the propeller and the diode or transistor, as well as on the contrast between propeller blades and background.

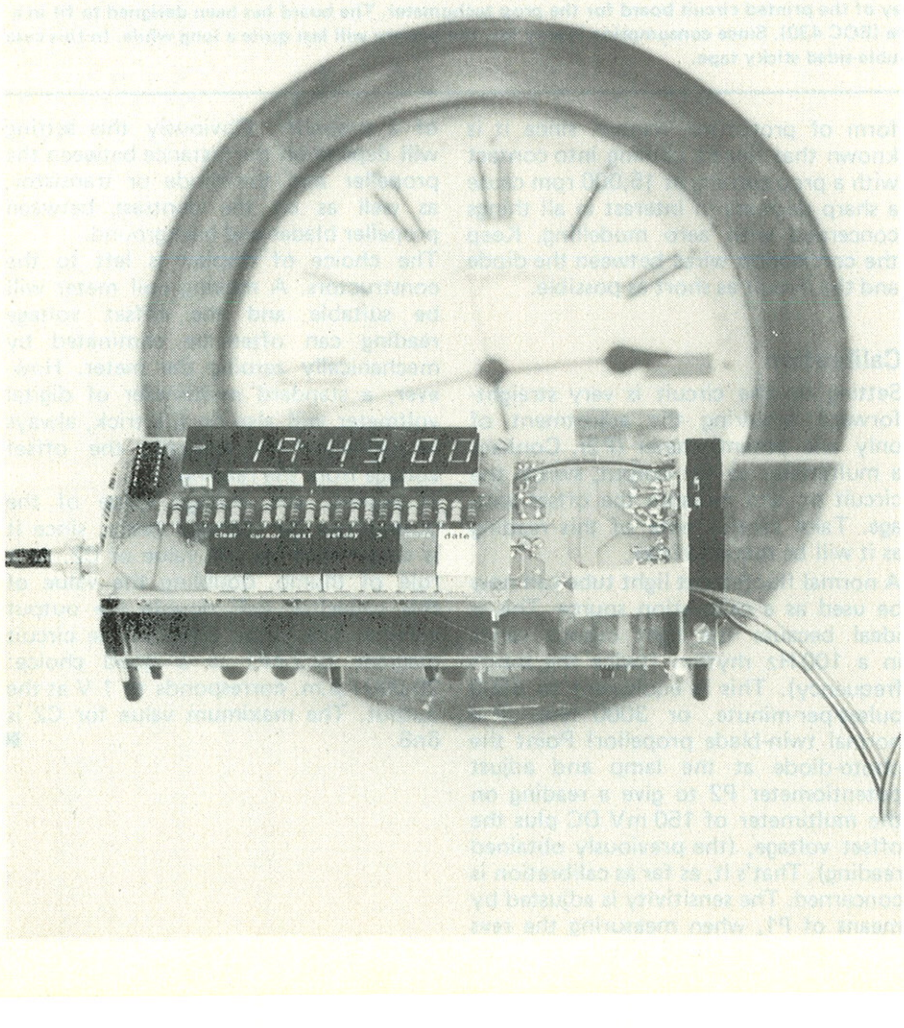
The choice of display is left to the constructors. A moving coil meter will be suitable and the offset voltage reading can often be eliminated by mechanically zeroing the meter. However, a standard multimeter of digital voltmeter will also do the trick, always remembering to subtract the offset voltage from the reading.

If desired, the voltage range of the output can be changed easily, since it is determined by the value of C2. As a rule of thumb, doubling the value of this capacitor will double the output voltage. The value given in the circuit diagram (2.2 nF) is a good choice: 20,000 r.p.m. corresponds to 1 V at the output. The maximum value for C2 is 6n8. ◀

6502 housekeeper

A programmable time-clock

With all the digital clocks and watches available today, it is surprising that time-switches are often such crude affairs. Given the relatively low cost of microprocessor chips, it seems 'logical' to do the job properly! This article describes a sophisticated time-clock, based on a 6502 microprocessor. It can be used to control a multitude of household appliances, such as cookers, burglar alarms and house lighting. Incidentally, since it must keep track of the time to do its job, it can also provide a digital display of time, day and date. In other words it is also a digital clock . . .



A 6502 microprocessor keeps track of the time and day of the week. It also calculates the date, even bearing leap years in mind, so that it will remain accurate until 'February 29th 2100' . . . (That is *not* a leap year, and most microprocessor-based 'perpetual calenders' go wrong at that point!).

Our electronic housekeeper is easily programmed. It provides four control outputs for switching purposes. Three of these are intended for 'daily needs' – 'on' and 'off' times are set on a 24-hours basis, and it is possible to select days of the week on which the sequence will not be executed. The times are accurate to within one minute. A fourth output is intended for a weekly cycle: ten 'on' and 'off' times are distributed over a seven-day period. The only restriction is that they must be set on a quarter-hourly basis.

The microprocessor checks the times entered; if a line seems to be switched off twice in succession, say, the 'housekeeper' will indicate this error immediately, during programming.

Obviously, this sort of thing requires an extensive program. A complete listing is included in this article, but we hope that enthusiasts will understand that we cannot explain it in detail . . . Describing the actual construction and operation of the time-clock takes up quite enough space as it is!

The hardware

Figure 1 contains the complete circuit diagram of the digital time-clock. At the heart of the circuit there is a 6502 CPU (IC1). The program for the clock and the switch functions is stored in a 2716 EPROM (IC3). The third large IC is a 6532 (IC2), which provides 16 I/O lines to control the display, scan the keys and read in the time data. In addition, the IC includes a timer (which generates seconds pulses) and another 128 bytes of RAM to store temporary data and the switch time entries.

Apart from the 16 I/O lines to IC2, an additional four output lines are needed for the different switching times. These are provided by the four-bit latch, IC4.

The clock generator is shown at the lower left in the circuit diagram. The output from a 4 MHz crystal oscillator is divided by four to obtain the 1 MHz clock signal. This division is done by two flipflops, FF1 and FF2. Another alternative would have been to use a 1 MHz crystal in the first place, but the solution used here is a much cheaper way to obtain a 'clean' squarewave.

When the unit is switched on, a '$\overline{\text{RES}}$' signal initiates the reset procedure. This signal is generated by the circuit around T1, T2, N3 and N4. Initially, T1 will not conduct but T2 will, effectively shorting capacitor C7 and ensuring that the output of N3 is at logic zero. T1 starts to conduct when the rising supply voltage reaches 4.5 V. As a result, T2 is turned off and C7 starts to charge.

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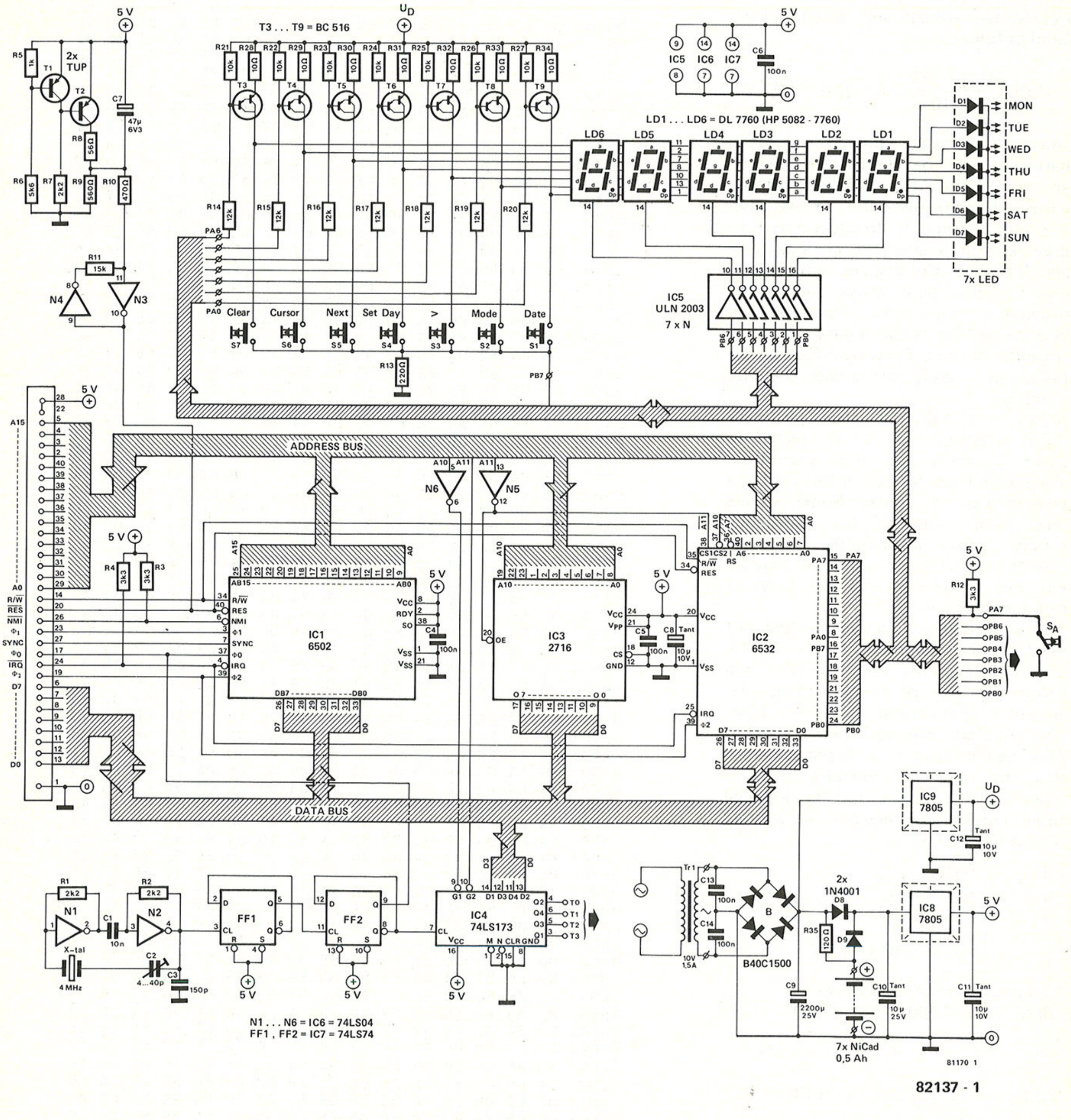

Figure 1. The circuit diagram of the programmable time clock. The 6502 CPU is situated at the centre of the circuit. The displays and their control unit are shown at the top and the power supply is located in the lower right-hand corner.

Due to the C7/R9 time constant, the output of N3 stays low for some time after the supply voltage has attained its nominal value. The circuit around N3 and N4 is included to 'sharpen up' the edges of the reset pulse. In passing, we can note that a reset pulse is also produced if the supply voltage briefly drops below the 4.5 V level for any reason, but this will be discussed later on.

One side of the six displays and 'days' LEDs is connected to the I/O lines by means of the buffer/inverters in IC5, and the other is linked to the darlington transistors, T3 . . . T9. The latter see to it that a constant current flows through the displays and the LEDs.

Two 5 V stabilisers, IC8 and IC9, produce the supply voltage. They both provide 5 V,IC9 feeding the LEDs and displays and IC8 looking after the rest of the circuit. This arrangement makes it easier to provide an emergency (NICAD) battery supply. The batteries are placed at the input of IC8. During normal mains operation, a 'topping-up' current flows continuously through the batteries by way of resistor R35. In the event of a power failure, the batteries will feed the main circuit via D9 and IC8. At the same time, a very low current will pass through the displays (by way of R35 and IC9). This system reduces the current consumption from 0.8 to 0.25 A, so that the NICAD batteries used here will be able to stand in for about one and half hours.

The charge current flowing through the batteries is determined by the value of R35. This in turn depends on the transformer voltage and may be calculated as follows:

$$R35 = \frac{U_{C9} - 10}{20 \cdot 10^{-3}} = 50\,U_{C9} - 500\ \Omega$$

During prolonged power cuts the batteries may be discharged to such an extent that the stabilised supply voltage drops below 4.5 V. In that case, the reset circuit will introduce a reset to prevent errors in the program execution and failure of the display multiplexing unit (which might cause one of the displays to burn out!). The reset will also cause the programmed switching times to be lost. Fortunately, a power failure will rarely last longer than 90 minutes!

Instead of NICADs, two ordinary 4.5 V batteries may be connected in series, in which case R35 is omitted. They will have to be replaced after a year or two, of course. Some readers may even consider this emergency supply totally superfluous, in which case the batteries, R35 and D9 may be left out altogether and D8 may be replaced by a wire link.

The address decoding system does not need to be complete and a simple circuit (using only two inverters) will suffice, because the memory range consists of only three blocks (IC2 . . . IC4). The processor can deal with a total of 64K memory, but what happens here is that the same 4K memory block is repeated throughout the range. The three blocks are decoded by address lines A10 and A11:

A11	A10	
0	0	IC2
0	1	IC4
1	0	IC3
1	1	

Memory is mapped as follows:

```
*000          *400          *800
 .             .             .
 :    IC2      :    IC4      :    IC3
 .             .             .
*3FF          *7FF          *FFF
```

(* = don't care)

The chosen structure is by no means coincidental. The EPROM is at the top end of memory, because that is where the NMI, RESET and IRQ vectors have to be fetched. IC2, the 'RIOT' (this stands for RAM, I/O, TIMER- — a well — organised IC, despite its name), is situated at the other end of the range for two reasons:

- Using the 6502 µP, 'zero page instructions (addresses 0000 . . . 00FF) are only 2 bytes long. If similar instructions are required on any other page they will consist of three bytes. This is a highly effective way in which to economise on memory space.
- Page 1 (0100 . . . 01FF) must contain RAM for the 'stack'. This requirement is met by not connecting address lines A8 and A9 to IC2 (RIOT will therefore occupy pages 0 . . . 3). This means that the 128 bytes of RAM in IC2 are used for two different purposes. The lower section belongs to page zero (0000 . . . 0069) for storing data (intermediate results and switching times), whereas the rest acts as the stack in page 1 (016A . . . 017F).

Finally, the address range between RIOT and EPROM is used for the latch (IC4).

```
HEXDUMP: 0800,0FFF
       0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
0800: D8 A9 FF AA E8 95 00 E0 3D D0 F9 A9 88 E8 95 00
0810: E0 47 D0 F9 A9 00 85 0F 85 21 8D 00 04 AA 95 48
0820: E8 E0 3E D0 F9 E6 4C E6 61 A9 7F 85 81 85 83 85
0830: 60 AA 9A 58 00 EA EA 20 44 09 C9 FF D0 F9 A5 87
0840: A2 00 A0 00 24 87 50 11 A2 00 E8 C8 20 8C 0B C0
0850: 28 F0 5C A5 80 10 F4 30 F1 20 8C 0B E8 E0 28 D0
0860: E3 A5 5F C9 59 D0 3F A2 96 20 8C 0B CA D0 FA A2
0870: 07 A0 06 20 9F 09 A2 05 B5 4F D5 55 D0 1F CA 10
0880: F7 A2 05 B5 55 95 4F 95 49 CA 10 F7 20 32 09 A2
0890: 08 86 61 A2 D8 86 9F 85 48 85 60 30 A1 A2 05 B5
08A0: 55 95 4F CA 10 F9 A2 FF 86 60 20 32 09 30 8F E0
08B0: 0A 90 F3 E0 1E 90 04 A9 80 D0 02 A9 00 85 63 A4
08C0: 5F C0 20 90 2B F0 3C A5 63 10 02 E6 5D A6 5E C0
08D0: 28 F0 38 C0 35 F0 32 C0 41 F0 3C C0 44 F0 42 C0
08E0: 49 F0 45 C0 57 F0 46 C0 58 F0 20 15 55 4A 95 55
08F0: A2 96 20 8C 0B CA D0 FA 18 98 F8 69 01 D8 85 5F
0900: 4C 3E 08 A5 63 30 E9 10 9D 56 55 46 5D B0 97 A9
0910: 00 85 5D E6 5E D0 D9 15 55 4A 4A 95 55 E6 5E D0
0920: CF 15 55 4A 4A 4A 10 F1 15 55 4A 10 EC 15 55 4C
0930: 1B 09 A2 0A A9 00 95 55 CA 10 F9 60 86 5B 84 5C
0940: 46 62 90 12 A2 02 B5 48 E0 02 D0 03 20 89 09 95
0950: 67 CA 10 F2 30 12 A5 4B 20 89 09 85 69 A5 4D 20
0960: 89 09 85 68 A5 4E 85 67 A6 4C A9 7F 38 6A CA D0
0970: FB 85 66 A5 60 F0 0A E6 11 E6 11 10 04 A9 FF 85
0980: 66 20 13 0B A6 5B A4 5C 60 A8 F0 06 C9 0F B0 02
0990: 09 F0 60 A0 00 20 0B 0A 49 60 D0 6E 99 48 00 20
09A0: 0B 0A 49 60 D0 64 99 49 00 20 0B 0A 49 24 D0 5A
09B0: 99 4A 00 20 0B 0A 20 0B 0A C9 08 D0 05 A9 01 99
09C0: 4C 00 B9 4B 00 C9 29 30 41 C9 31 30 11 6A 90 26
09D0: B9 4D 00 C9 08 10 02 49 FF 6A B0 1A 90 2C B9 4D
09E0: 00 C9 02 D0 25 B9 4E 00 29 13 F0 04 C9 12 D0 06
09F0: B9 4B 00 6A B0 14 A9 01 99 4B 00 20 0B 0A C9 13
0A00: D0 08 A9 01 99 4D 00 20 0B 0A 60 18 B5 48 F8 69
0A10: 01 D8 95 48 E8 60 48 98 48 8A 48 A9 00 85 81 A5
0A20: 82 85 64 C6 61 F0 08 A5 01 A9 79 85 9F D0 1B A9
0A30: 82 85 9E A5 1D F0 07 A5 48 D0 03 20 58 0A A2 00
0A40: 20 93 09 20 E9 0A A9 09 85 61 A5 64 85 82 A9 7F
0A50: 85 81 68 AA 68 A8 68 40 85 01 A2 02 A9 00 A8 8A
0A60: 0A 0A 0A 0A 85 0E B1 0E 0A A4 4C 0A 88 D0 FC 90
0A70: 08 A9 FE 25 01 85 01 B0 1F C8 C8 A5 4A D1 0E F0
0A80: 04 B0 0A 90 13 A5 49 C8 D1 0E 90 0C 88 C8 A9 01
0A90: 45 01 85 01 C0 09 D0 E2 06 01 CA 10 BF 66 01 E8
0AA0: E0 14 F0 25 20 D5 0A 98 C5 4C 90 F3 D0 1B B5 2A
0AB0: 4A 4A C5 4A F0 04 90 0E B0 0F B5 2A 29 03 A8 A5
0AC0: 49 D9 F3 0F 90 03 4C 9F 0A 8A 29 01 0A 0A 0A 05
0AD0: 01 8D 00 04 60 8A 48 4A AA B5 3E 90 08 4A 4A 4A
0AE0: 4A A8 68 AA 60 29 0F 10 F8 A2 00 8A 09 60 85 82
0AF0: 8A C9 09 D0 02 E8 8A 4A A8 90 09 B9 48 00 4A 4A
0B00: 4A 4A 10 03 B9 48 00 29 0F 09 30 85 82 E8 E0 0E
0B10: D0 D9 60 A9 40 85 1B A2 04 A9 02 85 1C B5 65 C6
0B20: 1C F0 27 30 29 4A 4A 4A 4A A8 B9 DB 0F A4 1B 84
0B30: 82 85 80 20 86 0B A5 21 C9 01 F0 07 25 1B F0 03
0B40: 20 86 0B 88 84 80 46 1B 10 D3 29 0F 10 DB CA F0
0B50: 09 E0 01 D0 C4 B5 65 4C 2D 0B A5 21 F0 04 C9 01
0B60: D0 03 20 86 0B A9 00 85 82 A9 BF 85 80 A5 82 D0
0B70: 09 A5 80 09 80 6A 85 80 B0 F3 A5 80 09 80 85 62
0B80: A2 FF 86 80 AA 60 A0 64 88 D0 FD 60 20 3C 09 C9
0B90: FD D0 F8 20 13 0B A2 7F 9A 20 44 0E 20 13 0B E8
0BA0: D0 FA 20 13 0B E8 F0 FA 20 13 0B E8 F0 F4 C9 EF
0BB0: F0 11 C9 BF F0 13 C9 DF F0 06 C9 FD F0 47 D0 E2
0BC0: 4C AF 0C 20 54 0E 4C 9C 0B A2 FF 86 69 86 68 A9
0BD0: 2A C5 0A F0 1D A9 02 C5 0B D0 02 86 66 A9 0A C5
0BE0: 0B F0 09 20 E6 0E E6 0B E6 0B 10 F1 20 48 0E 4C
0BF0: 9C 0B 86 66 20 E6 0E E6 0B A9 14 C5 0B D0 F5 20
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Construction and calibration

Figures 2 and 3 show the printed circuit boards for the digital time-clock. One board contains the displays, LEDs and keys and the other accommodates the processor, with its associated components and the power supply. The boards are designed to be mounted one on top of the other, with the copper sides facing each other. Be careful when wiring the boards and inserting them into a case. Some mounting holes are drilled through wide copper tracks. Use

```
0C00: 44 0E 4C 9C 0B 20 44 0E A9 02 C5 0B F0 25 A5 69
0C10: 85 1A A5 68 85 1B C6 0B C6 0B 20 7C 0E A5 69 C5
0C20: 1A F0 04 B0 5F 90 08 A5 68 C5 1B F0 02 B0 55 E6
0C30: 0B E6 0B A9 02 C5 0A D0 06 A9 08 C5 0B F0 06 20
0C40: 54 0E 4C 08 0C 20 48 0E A5 69 85 5B A5 68 85 5C
0C50: 20 D5 0A C0 08 F0 28 84 1A E8 86 0B 20 AF 0E 98
0C60: C5 1A 90 20 F0 02 B0 11 EA A5 69 C5 5B 90 15 F0
0C70: 02 B0 06 A5 68 C5 5C 90 0B A5 0B C9 13 D0 C9 C6
0C80: 1D 4C 37 08 A9 CD 85 69 A9 DA 85 68 A9 DF 85 67
0C90: A9 FF 85 66 85 0D 20 13 0B C6 0D D0 F9 A9 2A C5
0CA0: 0A F0 06 20 50 0E 4C 9C 0B 20 68 0E 4C 9C 0B A6
0CB0: 69 E8 D0 04 86 69 86 68 A9 80 85 21 A9 2A C5 0A
0CC0: F0 30 A9 02 C5 0B F0 2A 46 21 A9 0C C5 21 D0 04
0CD0: A9 04 85 21 A9 02 C5 21 F0 1B A9 40 C5 21 F0 1C
0CE0: 4A C5 21 F0 30 4A C5 21 F0 25 4A C5 21 F0 23 4C
0CF0: 83 0D 4C 96 0D A9 00 85 21 4C 9C 0B 20 4D 0F A5
0D00: 69 18 69 10 C9 24 90 02 A9 00 85 69 4C FC 0C 4C
0D10: 3C 0D 4C 6E 0D 20 4D 0F E6 69 A9 20 25 69 F0 0C
0D20: A5 69 C9 24 D0 EF A9 20 85 69 10 E9 A5 69 29 0F
0D30: C9 0A D0 E1 A9 F0 25 69 85 69 10 D9 A9 2A C5 0A
0D40: F0 13 20 4D 0F A5 68 18 69 10 C9 60 90 02 A9 00
0D50: 85 68 4C 42 0D A9 18 85 21 20 4D 0F 18 A5 68 F8
0D60: 69 15 D8 C9 60 D0 02 A9 00 85 68 4C 59 0D 20 4D
0D70: 0F E6 68 A5 68 29 0F C9 0A D0 F3 A9 F0 25 68 85
0D80: 68 10 EB 20 4D 0F A2 2A E4 0A D0 04 A2 FF 86 0A
0D90: 20 48 0E 4C 83 0D A9 00 85 21 20 97 0F E8 D0 FA
0DA0: 20 97 0F E8 F0 FA 20 97 0F E8 F0 F4 C9 DF F0 49
0DB0: C9 EF F0 4F C9 FB D0 E8 A9 2A C5 0A F0 4B A9 80
0DC0: 85 0C A9 FF 85 66 46 0C 20 B6 0F E8 D0 FA 20 B6
0DD0: 0F E8 F0 FA 20 B6 0F E8 F0 F4 C9 DF F0 1B C9 EF
0DE0: F0 21 C9 FB F0 0A C9 F7 D0 E4 A5 0C 45 66 85 66
0DF0: A9 01 C5 0C D0 D0 4C 9A 0D 20 E6 0E A9 80 85 21
0E00: 4C C8 0C 20 E6 0E 4C C3 0B A0 01 A6 0B F0 04 CA
0E10: 20 D5 0A B9 EA 0F 85 66 49 FF 85 0C 20 B6 0F E8
0E20: D0 FA 20 B6 0F E8 F0 FA 20 B6 0F E8 F0 F4 C9 FB
0E30: F0 07 C9 F7 D0 EC 4C 96 0D 46 0C A5 0C F0 CA 38
0E40: 66 66 30 D8 A9 FF 85 0A E6 0A A9 03 C5 0A F0 18
0E50: A9 00 85 0B A9 2A C5 0A F0 16 E6 0B E6 0B A9 0A
0E60: C5 0B F0 E4 20 7C 0E 60 A9 2A 85 0A A9 FF 85 0B
0E70: E6 0B A9 14 C5 0B F0 CC 20 AF 0E 60 A9 00 A8 85
0E80: 1D A5 0A 0A 0A 0A 0A AA 05 0B 85 1C B1 1C 85 69
0E90: E6 1C B1 1C 85 68 86 1C A5 0B 6A 6A 90 0D A9 0B
0EA0: 05 1C 85 67 86 1C B1 1C 85 66 60 A9 0A 10 F1 A5
0EB0: 0B AA B5 2A A8 C8 F0 23 29 FC 4A 4A 85 69 B5 2A
0EC0: 29 03 A8 B9 F3 0F 85 68 8A 4A 90 16 A9 0A 09 30
0ED0: 85 67 20 D5 0A B9 EA 0F 85 66 60 88 84 69 84 68
0EE0: 30 E6 A9 0B 10 E8 A5 0A C9 2A F0 18 0A 0A 0A 0A
0EF0: 85 1C A0 00 A5 66 91 1C A4 0B A5 69 91 1C C8 A5
0F00: 68 91 1C 60 A0 00 A5 0B AA A5 69 0A 0A 95 2A A5
0F10: 68 F0 0B C8 C9 15 F0 06 C8 C9 30 F0 01 C8 98 15
0F20: 2A 95 2A A0 00 A9 7F C8 38 6A C5 66 D0 F9 8A 4A
0F30: AA B5 3E 90 0E 29 0F 95 3E 98 0A 0A 0A 0A 15 3E
0F40: 95 3E 60 29 F0 95 3E 98 15 3E 95 3E 60 20 81 0F
0F50: E8 D0 FA 20 81 0F E8 F0 FA 20 81 0F E8 F0 F4 C9
0F60: DF F0 09 C9 EF F0 0F C9 FB D0 E8 60 BA E8 E8 9A
0F70: 20 E6 0E 4C C8 0C A9 00 85 21 BA E8 E8 9A 4C 03
0F80: 0E A5 21 85 1A E6 0D E6 0D 10 04 A9 00 85 21 20
0F90: 13 0B A4 1A 84 21 60 E6 0D A9 70 25 0D D0 12 A5
0FA0: 66 49 FF 85 66 20 13 0B A5 66 49 FF 85 66 A5 62
0FB0: 60 20 13 0B D0 F8 E6 0D E6 0D 10 14 A5 66 85 1A
0FC0: A5 0C 45 66 85 66 20 13 0B A5 1A 85 66 A5 62 60
0FD0: 20 13 0B D0 F8 18 90 FE FF FF FF 40 79 24 30 19
0FE0: 12 02 78 00 10 23 7B 06 2F FF FF BF DF EF F7 FB
0FF0: FD FE FF 00 15 30 45 FF FF FF D5 0F 00 08 16 0A
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insulated spacers and screws here, as otherwise something may well go up in smoke!

The 'day' LEDs can best be flat rectangular types (such as HP 5082-4670). The days of the week can be indicated on the LEDs by means of transfer lettering. Different shaped LEDs may also be used and the days may be printed next to each on the front panel. A third option is to mount an LED array in a DIL package (a set of 10 LEDs, such as the MV 57164, for example) and carefully remove three of them with a saw.

The two regulator ICs must be properly cooled. The back of the metal case can act as the heat sink if the regulators are mounted directly onto it, but mica insulation and washers must be used. The pins of the regulator ICs should be soldered onto the board, by the way, not wired. It is quite feasible to separate the supply section from the rest of the board, if desired, and mount it elsewhere in the case.

The boards are connected so that both sets of PB0 . . . PB6, PA0 . . . PA6 and PA7 pins are opposite each other. The connection points can then be linked with short lengths of wire. Then connect the three power supply connections on either board.

Once construction is complete you could insert all the ICs, connect the transformer to the mains and check whether everything is working satisfactorily. If something is wrong, it would be quite a problem to trace the error without a logic analyser. But there is another method, and a few hints on how to test the hardware using an oscilloscope or a multimeter can make all the difference.

Don't connect anything up for the moment, except for the stabilisers IC8 and IC9. Don't insert the other ICs into their sockets yet! The same applies to the batteries. Now check whether the output voltage of the two stabilisers is 5 V. Switch off the supply and insert IC6 and IC7. Switch on the power again and see whether there is a symmetrical 1 MHz squarewave at pin 8 of IC7. Readers who do not own an oscilloscope may use a multimeter instead and the auxiliary circuit in figure 4a. If the oscillator is working properly, the meter will indicate about 0 V. (A reasonably good frequency counter is needed to check the frequency; calibrate the oscillator with C2.)

Now find out whether $\overline{RES}$ (pins 9 and 10 of IC6) is logic 1. If so, the code 'AA' is applied to the data bus by means of several wires and resistors, as shown in figure 4b. The indicated numbers refer to the connector pin numbers between IC1 and IC3 on the board.

Time to insert the 6502 (IC1) in its socket (turn the power off first!). After power up, a symmetrical squarewave with a frequency of 250 kHz should appear at A0 (connector pin 29), 125 kHz at A1, 62.5 kHz at A2, and so on down to 7.6 Hz at A15. R/$\overline{W}$ (connector pin 14) must remain high. If one of the above conditions is not fulfilled, first check whether AA is in fact being applied to the data bus. Again, this measurement does not require an oscilloscope and can be carried out by means of the auxiliary circuit in figure 4c. The circuit is connected to all consecutive pairs of address lines in turn: A15 and A14, A14 and A13, A13 and A12 . . . A1 and A0. Each time the meter should read either 0 V or 5 V. Any intermediate value indicates a fault. It is best to check whether there is a 7 Hz squarewave at A15 first by connecting the meter to it. The pointer will 'flutter' at this very low frequency (provided you are using a moving coil meter). Then check all the address line pairs with the auxiliary circuit.

The 'AA code' is now disconnected from the data bus. Remember, no soldering while IC1 is on the board! It will have to be removed from its socket each time. The next step is to mount the EPROM, IC3 (with the power off, of course!). Before switching on the power

2

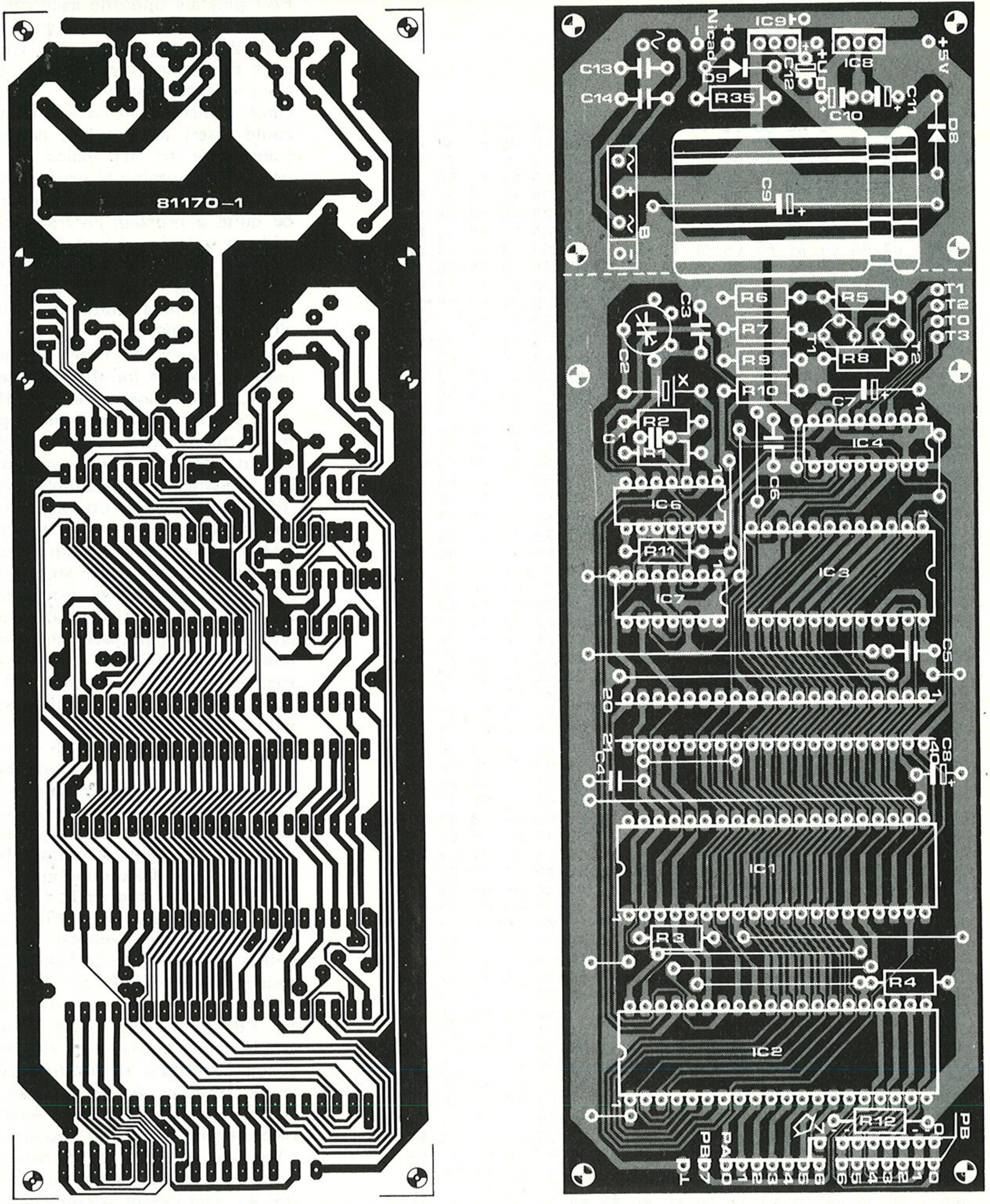


Figure 2. The main printed circuit board. This accommodates the entire microprocessor unit. The power supply section may be separated, if necessary.

Parts list

Resistors:
R1,R2,R7 = 2k2
R3,R4,R12 = 3k3
R5 = 1 k
R6 = 5k6
R8 = 56 Ω
R9 = 560 Ω
R10 = 470 Ω
R11 = 15 k
R13 = 220 Ω
R14 . . . R20 = 12 k
R21 . . . R27 = 10 k
R28 . . . R34 = 10 Ω
R35 = 120 Ω

Capacitors:
C1 = 10 n (cer.)
C2 = 4 . . . 40 p trimmer
C3 = 150 p
C4,C5,C6,C13,C14 = 100 n
C7 = 47 µ/6.3 V
C8,C11,C12 = 10 µ/10 V (tant.)
C9 = 2200 µ/25 V
C10 = 10 µ/25 V (tant.)

Semiconductors:
T1,T2 = TUP
T3 . . . T9 = BC 516
IC1 = 6502
IC2 = 6532
IC3 = 2716
IC4 = 74LS173
IC5 = ULN 2003
IC6 = 74LS04
IC7 = 74LS74
IC8,IC9 = 7805
D1 . . . D7 = LED red
see text
D8,D9 = 1N4001
B = B40C1500 bridge rectifier
LD1 . . . LD6 = DL 7760
(HP 5082-7760)

Miscellaneous:
Tr = 10 V/1,5 A mains transformer
S1 . . . S7 = digitast
X = 4 MHz crystal

3

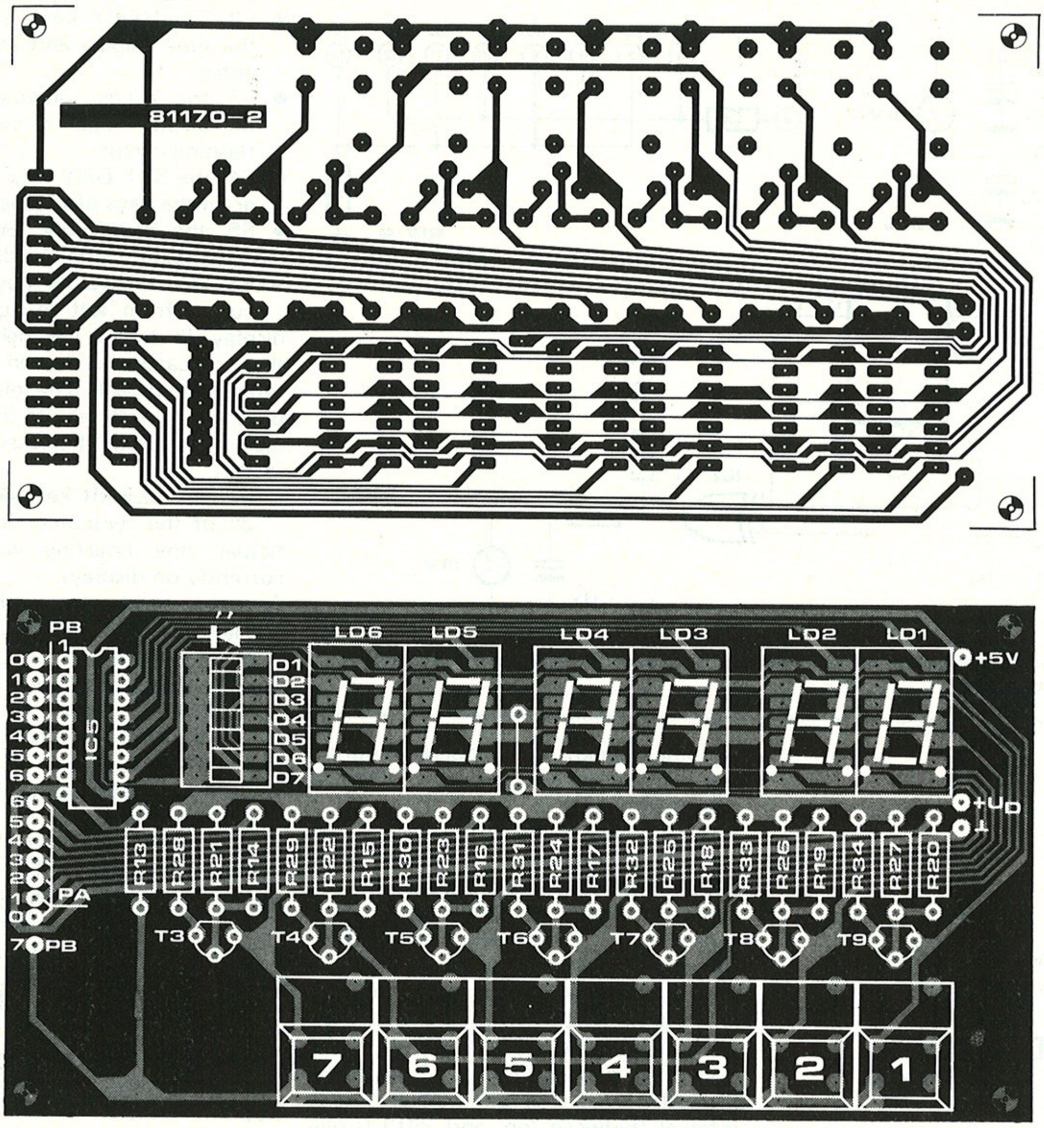


Figure 3. The display board contains the displays, LEDs, control electronics and pushbutton keys.

supply again, link pin 26 of the connector ($\overline{NMI}$) to pin 36 (A7). After power up, the address bus should read:

A15	A14	A13	A12	A11	A10	A9	A8
0	0	0	0	1	1	1	1

A7	A6	A5	A4	A3	A2	A1	A0
1	1	0	1	*	*	*	*

(A3 . . . A0 are not stable)

Furthermore, pin 20 of IC3 should be constantly low. If something is wrong, either the EPROM was not correctly programmed or N5 is not inverting the signal.

If everything is O.K. so far, pull out the mains plug for the last time, remove the connection between $\overline{NMI}$ and A7 and insert the remaining ICs. The clock should start to count from 00 00 01 as soon as the circuit is switched on.

Calibrating the crystal oscillator accurately is not an easy job. As mentioned earlier, the oscillator can be adjusted with C2, with a quality frequency meter connected to pin 8 of IC7. However, as few readers will be fortunate enough to own a really accurate frequency meter, here is an alternative method. It can be just as accurate, but it is rather more time-consuming . . .

First set the trimmer capacitor C2 in its centre position. Switch on a radio and wait for the time signal on the hour (1100, 1200, etc). Synchronise the clock on the sixth 'pip' of the radio time signal and press the start button. Let the clock run 'on its own steam' for several hours and then compare it to 'real time' again. Check whether the oscillator is 'fast' or 'slow' and readjust it with C2, if necessary. By repeating this procedure several times (over a period of a few days, if necessary) readers will be absolutely sure the oscillator is accurately calibrated.

Programming the timer

A pushbutton switch (S_A) is connected between the input and ground to start the time entry routine. Operation is as follows. After power up, the clock starts to count from 00 00 01. The clock is stopped by depressing S_A. The week/day LED then flashes. The desired day of the week may be selected with the > pushbutton (S3). Then the CURSOR key is operated (S6) and the tens/hour display starts to flash. The hours may be set by depressing > several times. The hours, minutes and seconds are all dealt with in the same manner. Once the 'second' units have been entered and the CURSOR key is operated again, the date will appear on the display. The same procedure is followed to enter the correct data, starting with the day and ending with the year (from left to right, in other words). Take care not to program an impossible date, as the clock might feel inclined to misbehave. After the year entry press the CURSOR key again. The time will then reappear on the display but no LEDs will flash. Now press the MODE key (S2) and the clock will start one second later. Readjust the time or date setting with the S_A key, if necessary. By the way, S_A doesn't have any effect unless the clock is 'ticking'!

4

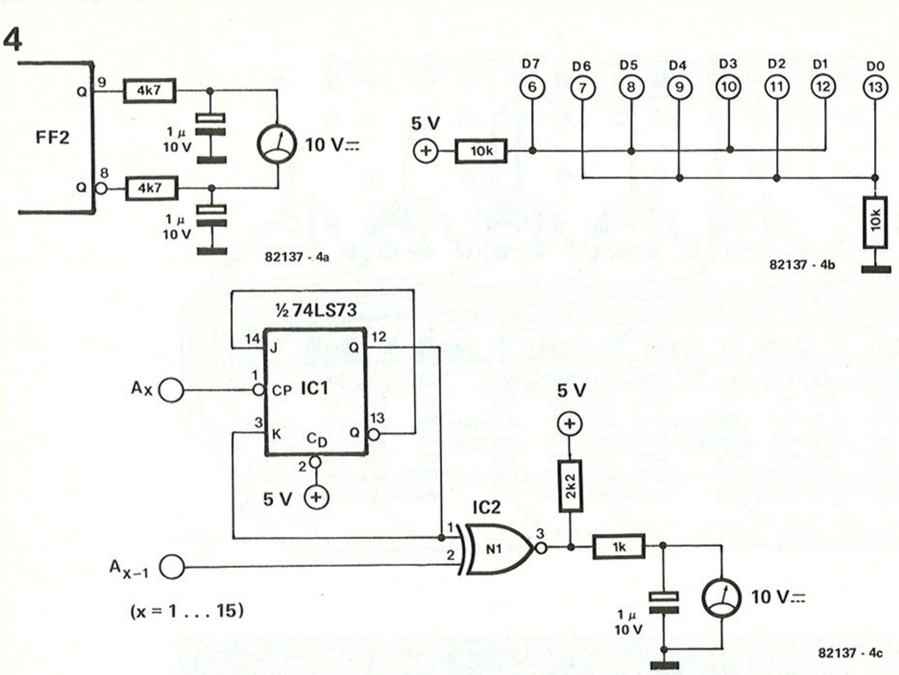


Figure 4. The auxiliary circuits for testing the digital time clock. They are only required if an oscilloscope is not available.

5

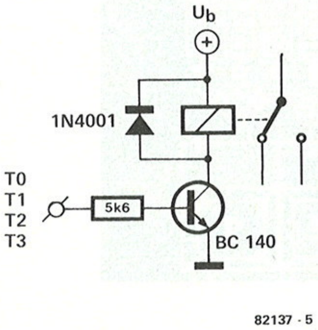


Figure 5. This tiny 'interface' enables outputs T0 . . . T3 to switch mains-powered equipment on and off.

Nothing happens if it is operated during the switch time entry routine, which is described below.

The four control outputs may be connected to any device that needs to be switched on or off at a specific time by means of a relay or a triac circuit. Outputs T0 . . . T2 can each program four switch times within 24 hours. In addition, the day of the week may be entered on which these switch times are to be processed. Every day at 00.00 hours the outputs T0 . . . T2 are automatically reset. The minimum switching interval (between 'on' and 'off') is one minute.

The fourth output, T3, can be programmed for a weekly cycle. It provides 10 'on' and 10 'off' times that can be set at fifteen-minute intervals. This line is automatically reset at the beginning of every week (at 00.00 hours on Monday morning).

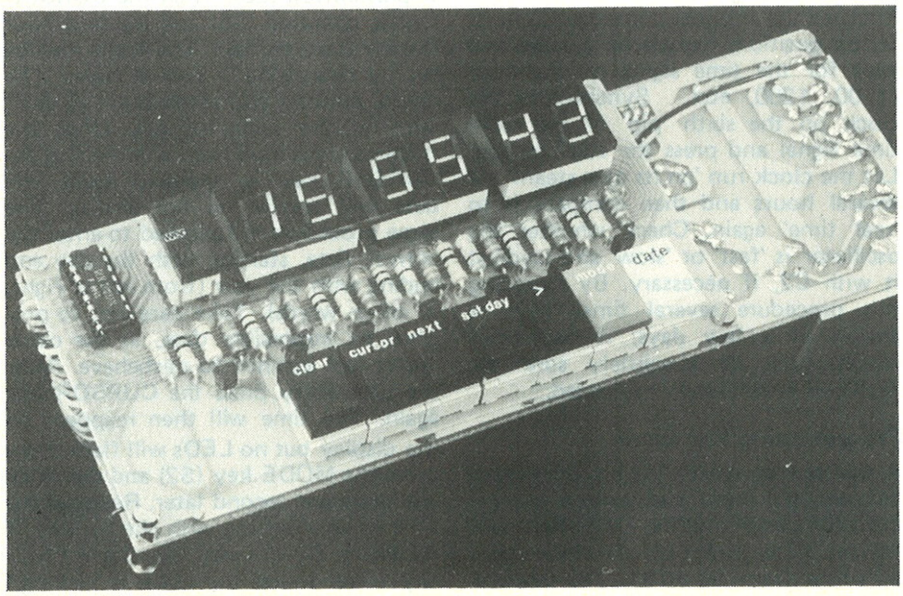
The switch functions are as follows:

- S1, the DATE key, displays the date.
- S2, The MODE key, selects between the time display and the switch time entry.
- S3, the > key, increments the value on display that is indicated by a flashing cursor.
- S4, the SET DAY key, serves to program the days of the week.
- S5, the NEXT key, shows the next switching time on the display.
- S6, the CURSOR key, moves the cursor from left to right across the display (but not the right-hand digit: that indicates whether an 'on' and 'off' time is involved). The display selected by the cursor flashes to indicate that it may be altered, if necessary, with the > key.
- S7, the CLEAR key, deletes some or all of the switching times on a particular line (starting with the time currently on display).

As mentioned above, the right-hand display indicates whether the switching time shown refers to 'on' or 'off'. 'On' is represented by a '1' and 'off' by a '0'. Its neighbour shows the line number (0, 1, 2 or 3). A program example is included in this article to illustrate how the various keys work, and to give an idea of the facilities.

A return to the normal time display routine causes T0 . . . T3 to be modified according to the entered switching times. This occurs exactly one second after every minute period. During programming of the switching times, the outputs remain unchanged.

One final point. If an 'off' time is programmed and this turns out to precede the 'on' entry, depressing the MODE key will cause an ERROR message to appear on the display for a few seconds, followed by the first time that is programmed for the line where the error occurs. No return can be made to the time display. First the error must be corrected, after which the MODE key is operated to switch the processor back to time display.



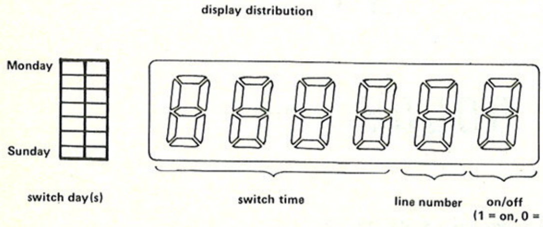
Switching mains-powered equipment

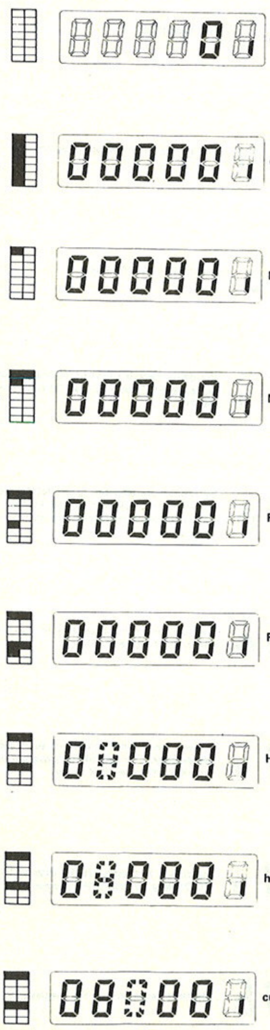
Readers who wish to switch mains-powered equipment 'on' and 'off' with the aid of the time switch require a small interface for each of the four switch outputs. Figure 5 provides a simple circuit for this purpose. The switch output controls a transistor by way of a resistor. The relay can then switch a device on and off. How much power may be switched depends on the type of relay. For the transistor shown, the relay current should not exceed 100 mA. If 12 V relays are to be used they may be connected directly to the time clock's power supply (across C9). This method ensures that the circuit is electrically isolated from the mains voltage. A solid state relay is of course equally suitable.

Program example

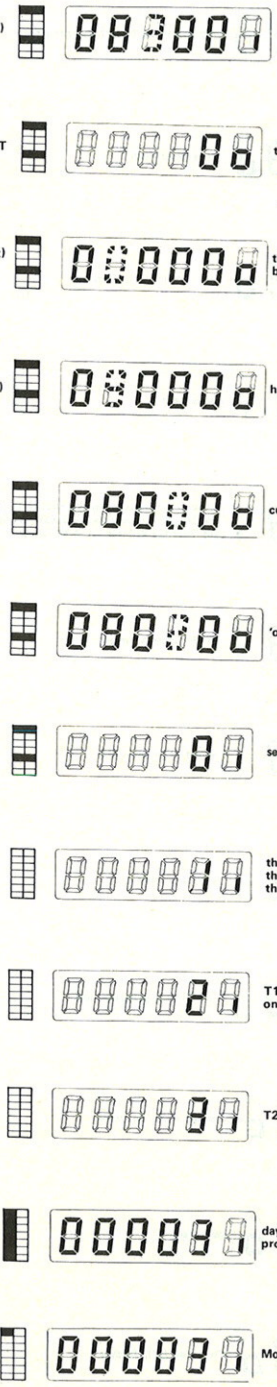
Switching times to be programmed:
line T0: switch on at 08.30 on Monday and Friday
switch off at 09.02
line T1: constantly '0'
line T2: constantly '0'
line T3: switch on at 20.00 on Sunday
switch off at 08.00 on Tuesday
switch on at 10.00 on Wednesday
switch off at 00.45 on Thursday

☐ indicates a day LED is unlit
■ indicates a day LED is lit
◧ indicates a day LED is flashing
8 indicates a display is flashing
8 indicates a display is lit

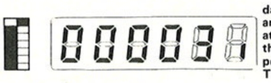
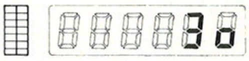
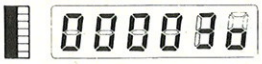
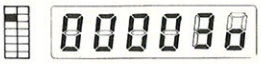
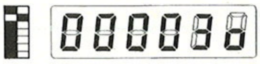
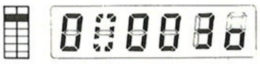
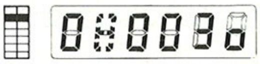
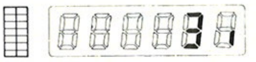
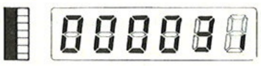
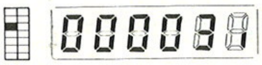
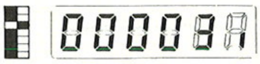
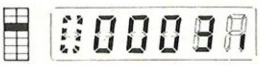
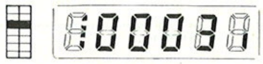
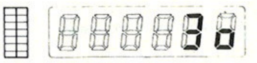
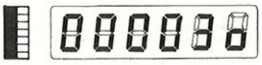
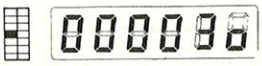
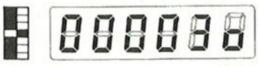
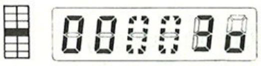
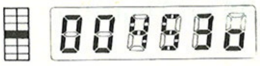
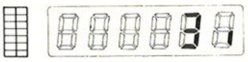
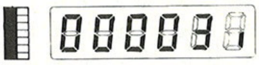
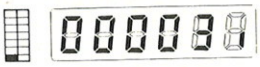
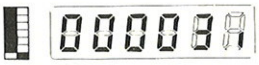
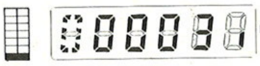
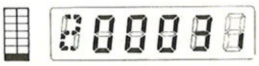
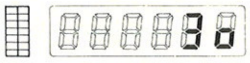
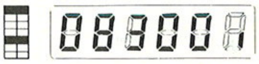
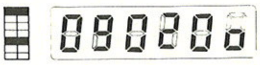
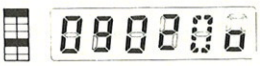
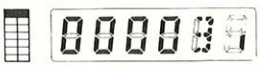
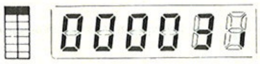
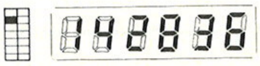




key	comments
MODE	change to switch time entry
CURSOR	days flash to indicate they may be programmed
>	Monday LED is flashing
SET DAY	Monday is stored
> (3x)	Friday LED is flashing
SET DAY	Friday is stored too
CURSOR (2x)	Hour units are flashing to indicate they may be changed
> (8x)	hour belonging to first switch-on time is programmed
CURSOR	cursor shifts one position to the right



key	comments
> (3x)	minute tens belonging to first 'on' time are programmed
NEXT	the next 'off' time is selected
CURSOR (2x)	the hours may be changed; the day LEDs do not have to be changed, because this line is programmed per day.
> (9x)	hours are programmed
CURSOR (2x)	cursor shifts two places to the right
> (2x)	'off' time of T0 is now stored
NEXT	select next switch time
CLEAR	the last two switch times of T0 are erased, because they are not needed. The display reports back with the first 'on' time of T1
CLEAR	T1 is not used and may therefore be erased. T2 appears on the display.
CLEAR	T2 is erased and T3 appears
CURSOR	days flash to indicate the first 'on' time of T3 may be programmed
>	Monday LED flashes

SET DAY		day belonging to first switch time is programmed and so is the first 'on' time. Since T3 is always reset at 00.00 on Monday morning, this will have to be the first 'on' time (because T3 has to be '1' for the period between 20.00 on Sunday and 08.00 on Tuesday)
NEXT		next 'off' time is selected
CURSOR		days flash to indicate they may be programmed
> (2x)		Tuesday LED flashes
SET DAY		day belonging to 'off' time is stored
CURSOR (2x)		hour units flash
> (8x)		'off' time is programmed
NEXT		days flash
CURSOR		after > is operated for the first time, Tuesday starts to flash to indicate that the next switchtime must be on Tuesday or later on in the week
> (2x)		Wednesday is stored
SET DAY		select next 'on' time
CURSOR		hour tens flash
>		'on' time is programmed
NEXT		select next 'on' time
CURSOR		days flash
> (2x)		Thursday LED flashes
SET DAY		Thursday is stored
CURSOR (3x)		both minute displays flash because T3 is programmed on a 15 minute basis. (For the first three lines, the minute displays could be programmed separately, as they can be adjusted for every minute.)
> (3x)		depressing the > key increments the minutes by 15. Now the 'off' time is programmed too.
NEXT		select the (last) 'on' time
CURSOR		days flash
> (4x)		Sunday LED flashes
SET DAY		Sunday is stored
CURSOR		hour tens flash
> (2x)		now all switch times are programmed
NEXT		select next switch time
CLEAR		the other switch times of T3 are erased, as they are not needed. Then the first T0 time reappears on the display
NEXT		by repeatedly depressing the NEXT key all the switch times may be checked. Of the deleted times, only the line number and the switch indication are visible.
CURSOR (5x)		the user may jump from line to line by setting the cursor to the line number.
> (3x)		In each case, the first time of every line appears on the display. The rest of the program may be stepped through with the NEXT key.
CURSOR		the cursor is moved off the display to allow the MODE key to return the processor to time display
MODE		the time reappears in the display.

RAM/EPROM card for the Z80

A. Seul

In principle, the RAM/EPROM card (as published in the Elektor September '80 issue) may be connected to a variety of microprocessors. One or two minor alterations to the control circuit are all that is necessary, in many cases, to match it to a particular system. This article describes the changes needed in order to interface the card to the Z80- and the Z80-A CPU, in particular, as this is introduced elsewhere in the present issue as the 'brain' behind the Polyformant.

Memory cards are basically birds of a feather. They all contain memory ICs, BUS buffers and a control circuit. The latter, however, does tend to vary from one system to another. The RAM/EPROM card described in the September '80 issue was originally designed for use with the SC/MP and 6502 systems, but after a couple of alterations it can be run on the Z80 as well. This involves changing the printed circuit board by breaking 9 tracks and then inserting 7 new wire links. No new components are required. In other words, it is just a 'cut and shunt' exercise.

Figures 1 and 2 show the changes that need to be made to the lower and component overlay sides of the printed circuit board, respectively. As can be seen, very little cutting and linking is required.

Reasons for the changes

The SC/MP and 6502 systems define both the address range and the direction in which the data transfer is to take place during either the read or write strobe produced by the CPU. In the Z80, on the other hand, a valid address may be output on three separate occasions: during normal memory access, when one of the 256 I/O addresses is being accessed and in the case of memory access during a refresh cycle. Taking into account the additional possibility of a non-valid address, only two CPU lines would seem to be required to define every possible address status. In actual fact, however, the Z80 processor uses three lines:

$\overline{MREQ}$ to access memory locations;
$\overline{IORQ}$ to access peripheral devices and
$\overline{RFSH}$ to access and refresh dynamic RAMs.

Let's forget about $\overline{IORQ}$ for the moment and see what happens in normal memory access and refresh cycles. During normal memory access the CPU starts by outputting addresses. After a short period, the $\overline{MREQ}$ signal is generated. This is accompanied by the $\overline{RD}$ strobe during a read cycle, in which case both signals will be synchronous. After the two signals the CPU stops reading data.

Things are different in the write cycle where the CPU produces the $\overline{MREQ}$ signal and simultaneously transmits the output data to the data bus. But the $\overline{WD}$ line is not enabled until after a brief interval to allow the active edge of the strobe to be used for data storage (provided the system is buffered in such a way that the data bus really does pass data to memory before the $\overline{WD}$ strobe arrives!). The $\overline{WD}$ signal is disabled at the same time as the $\overline{MREQ}$ signal.

The memory card may not be accessed during a refresh cycle. What happens here is that the refresh line is enabled first, after which the $\overline{MREQ}$ signal is strobed. $\overline{RD}$ and $\overline{WD}$ are not used, because the CPU ignores data during this particular process.

The control circuit of a memory device operates according to the following parameters:

1. Memory is accessed if $\overline{MREQ}$ is enabled and $\overline{RFSH}$ is disabled.
2. Data must be applied to RAM **before** the $\overline{WD}$ strobe is enabled.
3. Data must **only** enter the BUS while $\overline{RD}$ is enabled and memory is being accessed.

Figure 3 shows the circuit diagram of the modified memory board. The first parameter is met by linking $\overline{MREQ}$ and $\overline{RFSH}$ by way of N6 and N7. Pin 8 of N7 will then only go low, if the CPU addresses a memory location. The memory card should only react to a memory access if the relevant memory range is being selected. This is achieved by connecting pin 8 of N7 to pins 18 and 19 of IC5 (the 74154 decoder). Its outputs activate the CS decoder IC6 and IC7 by way of N1 and N2. In addition, the output of N5 produces an active high CARD SELECT signal.

The second requirement is fulfilled by making sure the card transfers data from the BUS to memory during its quiescent state. Thus, data will also be applied upon the arrival of the $\overline{WD}$ signal.

The 6502 processor implements the $\overline{WD}$ signal instead of its $\overline{RD}$ counterpart to transfer data to the data bus when memory is being accessed and the $\overline{WD}$ signal is disabled. In a Z-80 system, this would go hopelessly wrong: during a write cycle the CARD SELECT signal will precede the $\overline{WD}$ strobe. The original circuit 'notices' the signals and starts a read cycle. It will therefore transfer RAM data to the BUS until the write pulse $\overline{WD}$ appears. On the one hand, this prevents data from being applied to RAM upon the arrival of the $\overline{WD}$ strobe (second parameter) and on the other, the data bus is already being driven by the CPU buffers, as the CPU control circuit has acknowledged the write cycle. Bi-directional transfer is strictly forbidden in the BUS. Depending on which drivers are being operated, current peaks will be produced on the +5 V and GND lines, which could well make the system collapse.

To avoid these problems, the $\overline{RD}$ signal is inverted by way of N8 (and linked to the CARD SELECT signal by way of N3), and used to control the direction of data transfer in the data bus buffers. N4 serves to buffer the $\overline{WE}$ line, which has the arduous task of driving 16 ICs.

Inverters N6 and N8 and NAND gate N7 required for the modification are already included on the printed circuit board in IC29 (74LS00). In the original circuit, the unused inputs are either high or low to avoid crosstalk to active gates. These connections should now be replaced by the links indicated in figures 1b and 3. Once all these alterations have been made, the RAM/EPROM card will be ready for use with the Z80. ◀

1a

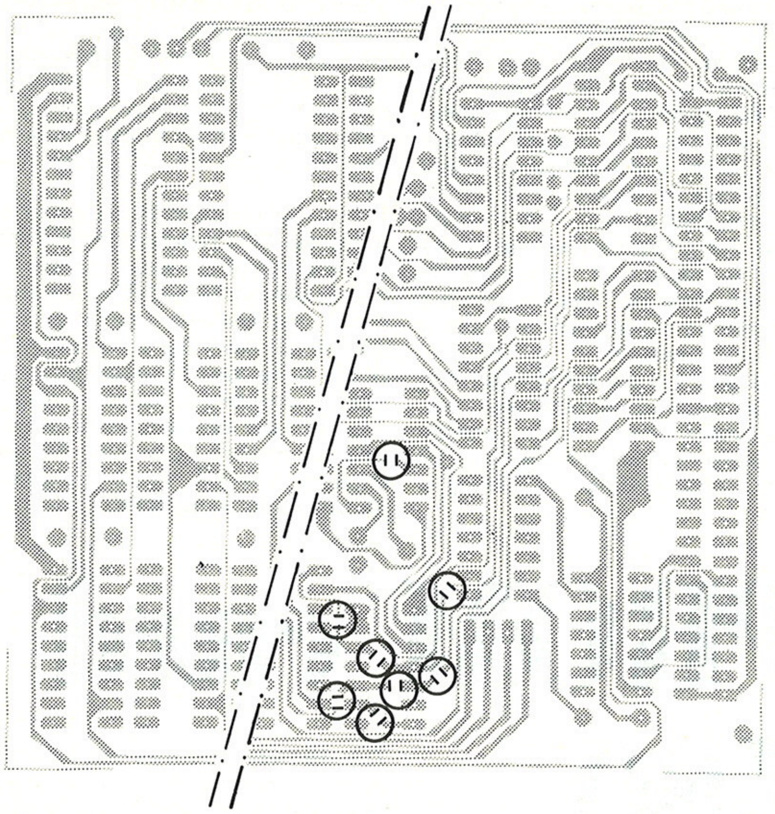


Figure 1a. The circles indicate which tracks on the lower side of the printed circuit board need to be broken.

1b

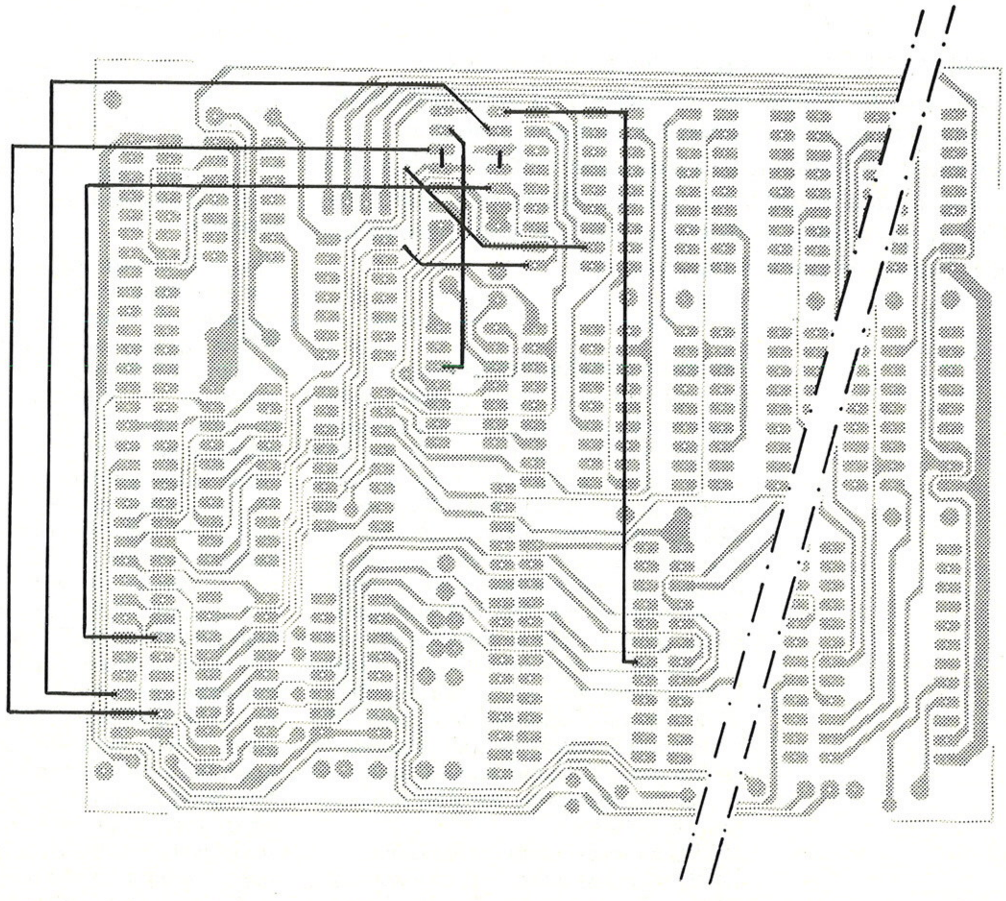


Figure 1b. The new wire links on the lower side.

2

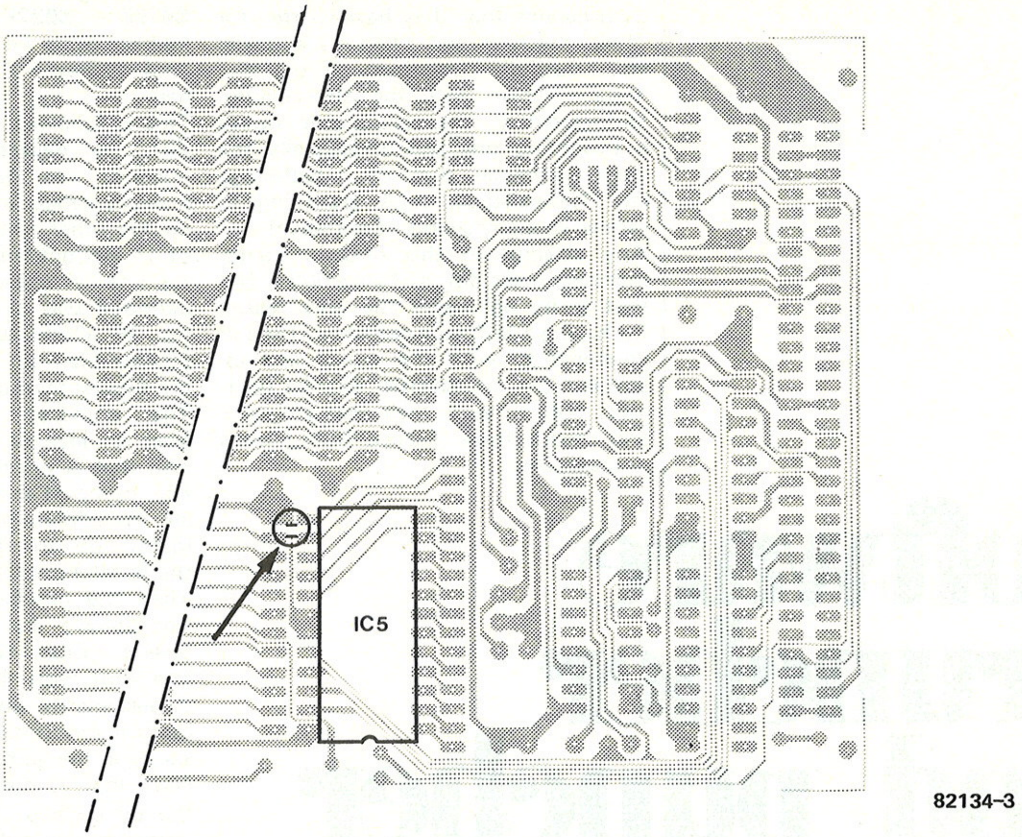


Figure 2. Only one track needs to be broken on the component overlay side.

3

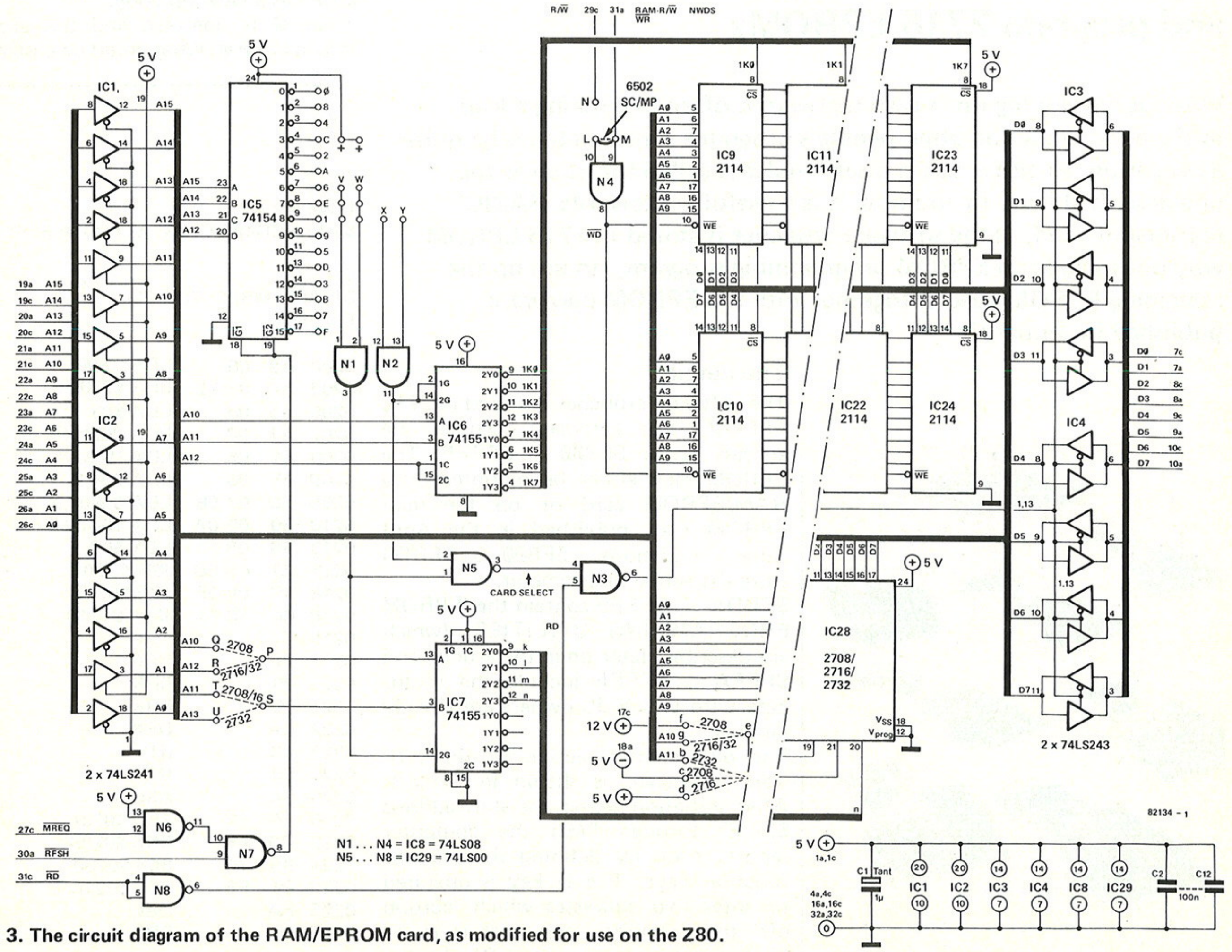


Figure 3. The circuit diagram of the RAM/EPROM card, as modified for use on the Z80.

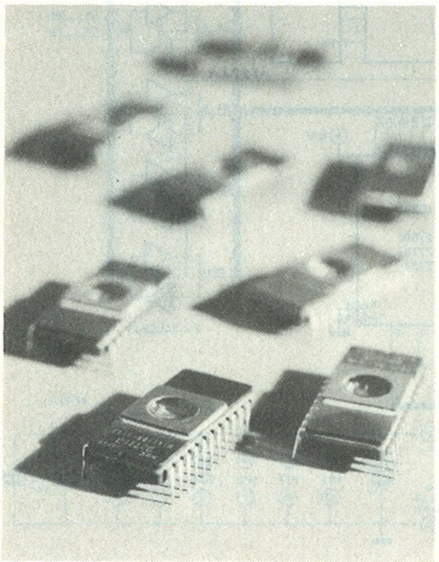
software cruncher and puncher

disassemble Junior Computer software and program 2716 EPROMs

Whereas developing one's own software is often like taking a leap in the dark, analysing other people's programs can sometimes be quite a revelation. In either case a disassembler is called for, such as the one described here. In addition, it is a useful aid towards 'BASIC' conversion. And, as the software cruncher is stored in 2716 EPROM, why not include an EPROM programming program, (to use up the remaining EPROM space), together with the EPROM hardware published in January?

Junior Computer owners regularly send us programs that they have written for 'their' machine and Elektor's editorial staff dutifully try them all out and 'unravel' them with the disassembler. Unfortunately, the task is not always a rewarding one and occasionally the work resembles that of a pathology lab. Nevertheless, it is gratifying to receive so many sparks of initiative!

Any attempt in this direction automatically calls for a disassembler, but that is by no means the only reason for having a 'software cruncher'. Used in combination with the editor and assembler the disassembler enables operators both to write their own programs and decode those gleaned from friends or magazines.



The details

The software cruncher is stored in 2716 EPROM. The software occupies the address range $F800 . . . $FFFF. The EPROM may either be mounted on a RAM/EPROM card or on the mini EPROM card published in the April issue. Locations $F800 . . . $FDD9 store the actual disassembler.

$FDDA . . . $FFF9 contain the 'EPROM PROGRAMMING UTILITIES' (which are described later on in the article) and $FFFA . . . $FFFF include the vector data with which JC owners are already familiar.

The disassembler section of the software 'cruncher' is shown in Table 1. After initiation (enter the start address $FC4E through PM!) the computer reports back by defining the relevant function keys. The D key is operated to enter two addresses which 'cordon off' the memory range that is to be disassembled (ending in CR). In the example given in Table 1 this comprises $0200 . . . $022F. Note that the end address must be entered and that the 'end address + 1' rule does not apply here.

This is followed by the message 'L, P, SP?'. By depressing the L key the operator can disassemble the entire memory range 'in one go'. The P key, on the other hand, does this in blocks of 15 instructions (a full TV screen, the top line being the last one to be printed *before* P was operated) and the space bar SP allows each instruction to be disassembled in turn and is therefore the slowest method.

The 'crunched' program in Table 1 gives an idea of the type of information that is printed. Table 2 shows the Hex dump of the disassembler. First of all, the address and the op code of the instruction are displayed followed by the byte(s) contained in the instruction. Then the mnemonics (the instruction 'shorthand') are printed preceded by several spaces. Wherever relevant, the line ends with the operand data. The displacements involved in conditional jump instructions are 'translated', so to speak, as the 'jump address'.

Data that is not acknowledged to be the op code of an instruction has the mnemonic consisting of three American AT symbols assigned to it (see address 021E, for example). Such data is one byte long. Note that FF is not acknowledged as a label op code.

Then R is operated and the program returns to PM. What could be easier?

Table 1.

```
FC4E
FC4E A9 R
VALID COMMANDS: A D H L P R SP

D
DISASSEMBLE: 200, 22F
L, P, SP ?
L
0200  A9  00      LDA# $00
0202  AD  01 02   LDA $0201
0205  A5  03      LDA $03
0207  A1  04      LDA ($04,X)
0209  B1  05      LDA ($05),Y
020B  B5  06      LDA $06,X
020D  BD  07 08   LDA $0807,X
0210  B9  09 0A   LDA $0A09,Y
0213  B6  0B      LDX $0B,Y
0215  20  0C 0D   JSR $0D0C
0218  4C  0E 0F   JMP $0F0E
021B  6C  10 11   JMP ($1110)
021E  77          @@@
021F  FF          @@@
0220  00          BRK
0221  00          BRK
0222  CA          DEX
0223  C8          INY
0224  E8          INX
0225  0A          ASL A
0226  F0  12      BEQ $023A
0228  D0  FE      BNE $0228
022A  B0  34      BCS $0260
022C  90  EE      BCC $021C
022E  FA          @@@
022F  00          BRK
```

1

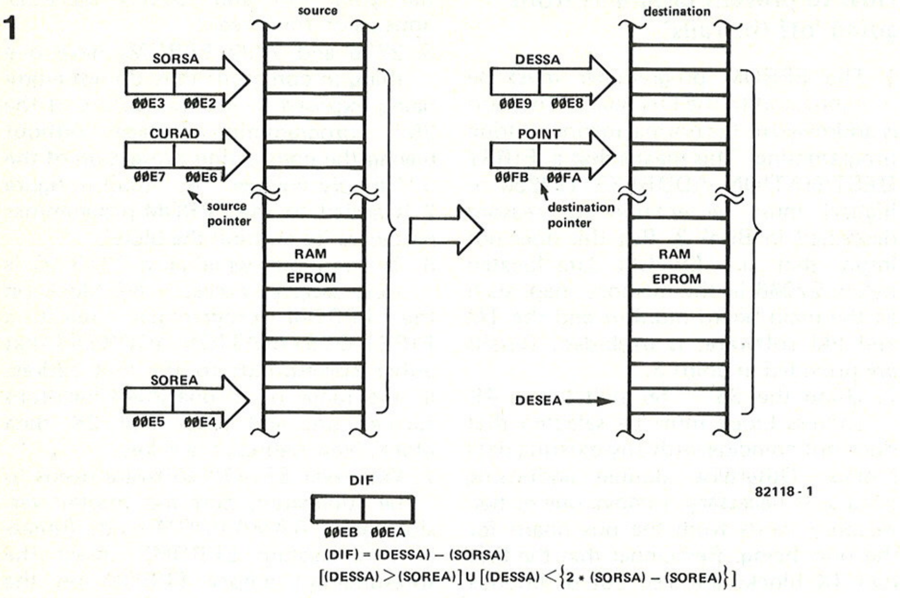


Figure 1. The memory ranges involved in the EPRUTL routine. Operating the M, R, V or F key causes the CURAD and POINT pointers to move through every location from SORSA and DESSA to SOREA and DESEA, respectively.

As for the H and A keys, depressing H is equivalent to operating M during PM and A represents 'ASCII dump'. Thus, a hex dump is printed after two address entries followed by CR (see table 2). The A key causes a hex dump to be printed showing the ASCII code of any alphanumeric character within the $20 . . . $7E range. In the case of data outside this range, a space appears. This feature allows data, such as computer messages that need printing, to be located swiftly. Once readers manage to crunch the disassembler they will see that this is riddled with such messages.

Not only, but also . . .

The printing operation of the dump or listing may be interrupted by depressing the BRK key. The BRK jump vector leads the 6502 μP to a central point in the program where it waits for a (new) key to be operated.

When two addresses are entered for the purpose of defining a listing or dump, the second address must be higher than the first. Otherwise, the two addresses will have to be re-entered, only this time in the right order please!

As well as storing data in much used memory locations in pages 00 and 1A, the software cruncher must dispose of $0010 . . . $0027. $0028 must now also be added to accommodate the extra software. Operators must be careful not to use these memory locations for the program they wish to 'sort out'.

Software puncher

As mentioned earlier, now that we have the necessary hardware (Elektor January 1982), a start can be made on loading RAM or EPROM software into 2716s. The program is started by way of PM at address $FDDA. After initialisation, the name of the program is printed along with a list of valid keys. Then the *parameter key, P,* should be depressed so as to define the address range by entering three addresses, as shown in figure 1. First of all, the 'FIRST, LAST SOURCE ADDRESS' must be specified, in other words, the SORSA and SOREA addresses at either end of the data block that is to be stored or relocated. Make sure SOREA has a higher number than SORSA, as otherwise the entry procedure (first address – comma – last address – CR) will have to be repeated. Next, enter the 'FIRST DESTINATION ADDRESS'. This is known as DESSA and determines the location of the first address belonging to the data being programmed or moved. (Enter the first address followed by CR.)

The following key functions are valid:

The M (MOVE) key ensures that the SORSA . . . SOREA data block is stored or relocated (provided the EPROM programmer is connected and prepared for programming – more about this later) into the destination block DESSA . . . DESEA. For reasons involving the V key, the two blocks may not overlap. The three address pointers must be set according to the parameters indicated in figure 1. At the end of the program 'DATA MOVED' appears on the screen/is printed.

The F (FF check) key enables the operator to check whether locations DESSA . . . DESSA + n – 1 contain FF (n represents the number of memory locations in the data block being programmed). If so, data may be stored in that particular range. The address and contents of any memory locations that do not contain FF are printed. Once all 'n' locations have been run through, 'DATA COMPARED' appears.

```
F800: A0 00 B1 10 85 12 29 0F 85 13 A5 12 4A 4A 4A 4A
F810: 85 14 4A 90 1E A9 01 85 15 A2 04 A5 13 DD B0 FB
F820: F0 15 CA 10 F8 A2 19 A5 12 DD B5 FB F0 0F CA 10
F830: F8 30 2A A9 00 F0 E0 A5 12 C9 A2 F0 0E A2 01 86
F840: 20 86 16 A2 08 20 12 FC 4C 81 F8 A2 02 86 16 A2
F850: 61 86 21 A2 30 86 22 20 FF FB 4C 0B F9 A2 01 E4
F860: 13 D0 43 E8 86 16 20 ED FB A5 15 F0 22 20 F2 FA
F870: 28 24 03 A0 01 B1 10 20 D8 FB 20 F2 FA 29 2C 59
F880: 03 18 A5 10 65 16 85 10 A5 11 69 00 85 11 60 20
F890: F2 FA 28 24 03 A0 01 B1 10 20 D8 FB 20 F2 FA 2C
F8A0: 58 29 03 4C 81 F8 A2 05 E4 13 D0 2F A2 02 86 16
F8B0: 20 ED FB A5 15 F0 15 20 F2 FA 24 03 A0 01 B1 10
F8C0: 20 D8 FB 20 F2 FA 2C 58 03 4C 81 F8 20 F2 FA 24
F8D0: 03 A0 01 B1 10 20 D8 FB 4C 81 F8 A2 09 E4 13 D0
F8E0: 3A A5 15 F0 1F A2 03 86 16 20 ED FB 20 F2 FA 24
F8F0: 03 A0 02 B1 10 20 D8 FB 88 D0 F8 20 F2 FA 2C 59
F900: 03 4C 81 F8 A2 02 86 16 20 ED FB 20 F2 FA 23 24
F910: 03 A0 01 B1 10 20 D8 FB 4C 81 F8 A2 0D E4 13 D0
F920: 35 A2 03 86 16 20 ED FB A5 15 F0 18 20 F2 FA 24
F930: 03 A0 02 B1 10 20 D8 FB 88 D0 F8 20 F2 FA 2C 58
F940: 03 4C 81 F8 20 F2 FA 24 03 A0 02 B1 10 20 D8 FB
F950: 88 D0 F8 4C 81 F8 A2 06 E4 13 D0 32 A2 02 86 16
F960: 20 FF FB A2 09 E4 14 F0 10 A2 0B E4 14 F0 0A A5
F970: 15 F0 03 4C B7 F8 4C CC F8 20 F2 FA 24 03 A0 01
F980: B1 10 20 D8 FB 20 F2 FA 2C 59 03 4C 81 F8 A2 0E
F990: E4 13 D0 1A A2 03 86 16 20 FF FB A2 0B E4 14 F0
F9A0: 0A A5 15 F0 03 4C 2C F9 4C 44 F9 4C EC F8 A2 00
F9B0: E4 13 D0 7A A5 12 C9 00 F0 26 C9 40 F0 22 C9 60
F9C0: F0 1E C9 20 F0 10 29 1F C9 10 F0 1E A2 02 86 16
F9D0: 20 10 FC 4C 0B F9 A2 03 86 16 20 10 FC 4C 44 F9
F9E0: A2 01 86 16 20 10 FC 4C 81 F8 A2 02 86 16 20 10
F9F0: FC A0 01 B1 10 10 17 20 13 FB 49 FF 85 19 38 A5
FA00: 17 E5 19 85 17 A5 18 E9 00 85 18 4C 1C FA 20 13
FA10: FB 38 65 17 85 17 A9 00 65 18 85 18 20 F2 FA 24
FA20: 03 A2 01 B5 17 20 D8 FB CA 10 F8 4C 81 F8 A2 04
FA30: E4 13 D0 11 A2 02 86 16 20 1F FC A5 15 F0 03 4C
FA40: B7 F8 4C CC F8 A2 0C E4 13 D0 2F A2 03 86 16 20
FA50: 1F FC A5 12 C9 6C F0 0A C9 BC F0 03 4C 44 F9 4C
FA60: 2C F9 20 F2 FA 28 24 03 A0 02 B1 10 20 D8 FB 88
FA70: D0 F8 20 F2 FA 29 03 4C 81 F8 A2 0A E4 13 D0 1C
FA80: A2 01 86 16 A6 14 E0 07 90 06 20 30 FC 4C 81 F8
FA90: 20 30 FC 20 F2 FA 20 41 03 4C 81 F8 A2 01 86 16
FAA0: 20 3F FC 4C 81 F8 20 DB FB CA D0 FA 60 20 D8 FB
FAB0: 4C DB FB 20 CF FB A5 11 20 D8 FB A5 10 20 AD FA
FAC0: A0 00 A2 0F B1 10 20 AD FA CA CA CA C8 C4 16 D0
FAD0: F3 20 A6 FA 60 20 B3 FA A2 03 A0 05 A9 00 06 22
FAE0: 26 21 2A 88 D0 F8 09 40 20 D2 FB CA D0 EC 20 DB
FAF0: FB 60 68 85 23 68 85 24 E6 23 D0 02 E6 24 A0 00
FB00: B1 23 C9 03 F0 06 20 D2 FB 4C F8 FA A5 24 48 A5
FB10: 23 48 60 A6 10 A4 11 E8 D0 01 C8 86 17 84 18 60
FB20: 7C 0B 2B 09 9D 61 1B 98 82 88 E4 06 02 02 60 86
FB30: 0C 93 64 93 9D 61 21 4B D8 D8 E4 E4 30 30 46 86
FB40: 14 14 54 13 95 15 95 15 00 10 61 10 1C 13 1C 11
FB50: 96 18 E4 52 12 86 26 A6 00 C6 32 E6 32 8A 30 62
FB60: FF 12 53 53 9D 61 1C 1C FE 68 60 60 32 32 32 30
FB70: 0C FF 93 FF 64 FF 93 FF A6 A6 A0 A4 21 FF 73 FF
FB80: D8 FE D8 FE E4 FE E4 FE 02 26 70 F0 70 FE E0 FE
FB90: 82 1B 83 99 82 1B 83 99 21 A6 A0 1B 4B 1B 4B 99
FBA0: 20 06 20 46 02 12 02 52 72 42 72 2C B2 08 B0 48
FBB0: 02 03 07 0B 0F 80 04 14 34 44 54 64 74 D4 F4 89
FBC0: 1A 3A 5A 7A DA FA 0C 1C 3C 5C 7C 9C DC FC 9E 4C
FBD0: E8 11 4C 34 13 4C AE 12 4C 8F 12 4C F3 11 4C 87
FBE0: 13 4C 68 12 4C 13 12 4C 9B 12 4C 5F 10 A5 14 4A
FBF0: AA BD 20 FB 85 21 BD 28 FB 85 22 20 D5 FA 60 A5
FC00: 14 4A AA BD 30 FB 85 21 BD 38 FB 85 22 4C FB FB
FC10: A6 14 BD 40 FB 85 21 BD 50 FB 85 22 4C FB FB A5
FC20: 14 4A AA BD 60 FB 85 21 BD 68 FB 85 22 4C FB FB
FC30: A6 14 BD 70 FB 85 21 BD 80 FB 85 22 4C FB FB A6
FC40: 14 BD 90 FB 85 21 BD A0 FB 85 22 4C FB FB A9 7E
FC50: A2 FC 8D 7C 1A 8E 7D 1A 20 F2 FA 0D 0A 56 41 4C
FC60: 49 44 20 43 4F 4D 4D 41 4E 44 53 3A 20 41 20 44
FC70: 20 48 20 4C 20 50 20 52 20 53 50 0D 0A 03 20 CF
FC80: FB 20 D5 FB C9 44 D0 3B 20 F2 FA 0D 0A 44 49 53
FC90: 41 53 53 45 4D 42 4C 45 3A 20 03 20 E1 FB 20 DE
FCA0: FB 30 DB 20 C5 FD 90 D6 AD 63 1A AE 64 1A 85 10
FCB0: 86 11 20 F2 FA 0D 0A 4C 2C 50 2C 53 50 20 3F 03
FCC0: 4C 7E FC C9 50 D0 20 A9 0F 85 25 85 26 38 AD 65
FCD0: 1A E5 10 AD 66 1A E5 11 90 A7 20 00 F8 A5 25 F0
FCE0: EC C6 26 D0 E8 F0 9A C9 4C D0 06 A9 00 85 25 F0
FCF0: DC C9 20 D0 08 A9 01 85 25 85 26 D0 D0 C9 48 D0
FD00: 1F A9 01 85 27 20 F2 FA 0D 0A 48 45 58 20 44 55
FD10: 4D 50 3A 20 03 20 E1 FB 20 DE FB 10 06 4C 7E FC
FD20: 4C A5 FD 20 C5 FD 90 F5 20 CF FB 20 CF FB A2 06
FD30: 20 A6 FA A0 00 98 20 E7 FB A2 02 20 A6 FA C8 C0
FD40: 10 D0 F2 AD 63 1A 85 FA AD 64 1A 85 FB 20 CF FB
FD50: 20 CF FB A2 10 86 26 A5 FB 20 D8 FB A5 FA 20 D8
FD60: FB 20 F2 FA 3A 20 03 AD 65 1A 38 E5 FA AD 66 1A
FD70: E5 FB B0 03 4C 7E FC A0 00 B1 FA A6 27 F0 0F 20
FD80: D8 FB 20 DB FB 20 E4 FB C6 26 D0 DB F0 C2 C9 20
FD90: 90 0F C9 7F B0 0B 20 D2 FB A2 01 20 A6 FA 4C 82
FDA0: FD A2 02 D0 F6 C9 41 D0 2A A9 00 85 27 20 F2 FA
FDB0: 0D 0A 41 53 43 49 49 20 44 55 4D 50 3A 20 03 4C
FDC0: 15 FD 4C 7E FC AD 65 1A 38 ED 63 1A AD 66 1A ED
FDD0: 64 1A 60 C9 52 D0 EB 4C EA FB A9 BF A0 FF 8D 7A
FDE0: 1A 8C 7B 1A 20 F2 FA 0D 0A 45 50 52 4F 4D 20 50
FDF0: 52 4F 47 52 41 4D 4D 49 4E 47 20 55 54 49 4C 49
FE00: 54 49 45 53 0D 0A 56 41 4C 49 44 20 43 4F 4D 4D
FE10: 41 4E 44 53 3A 20 50 2C 4D 2C 42 2C 56 2C 46 2C
FE20: 52 03 20 CF FB 20 D5 FB C9 50 D0 7A 20 F2 FA 0D
FE30: 0A 46 49 52 53 54 2C 4C 41 53 54 20 53 4F 55 52
FE40: 43 45 20 41 44 44 52 45 53 53 3A 20 20 03 20 E1
FE50: FB 20 DE FB 30 D6 20 C5 FD 90 D1 AD 63 1A AC 64
FE60: 1A 85 E2 84 E3 AD 65 1A AC 66 1A 85 E4 84 E5 20
FE70: F2 FA 0D 0A 46 49 52 53 54 20 44 45 53 54 49 4E
FE80: 41 54 49 4F 4E 20 41 44 44 52 45 53 53 3A 20 20
FE90: 03 20 E1 FB 20 A2 13 30 D6 AD 65 1A AC 66 1A 85
FEA0: E8 84 E9 4C 22 FE C9 4D D0 2B 20 D3 1E 20 8C FF
FEB0: A0 00 B1 E6 91 FA 20 13 12 A9 01 85 F6 20 A3 FF
FEC0: B0 EE 20 F2 FA 0D 0A 44 41 54 41 20 4D 4F 56 45
FED0: 44 03 4C 22 FE C9 42 D0 03 4C EA FB C9 56 D0 3B
FEE0: A9 00 85 28 20 D3 1E 20 8C FF A0 00 A5 28 D0 35
FEF0: B1 E6 D1 FA F0 03 20 F8 11 20 13 12 A9 01 85 F6
FF00: 20 A3 FF B0 E5 20 F2 FA 0D 0A 44 41 54 41 20 43
FF10: 4F 4D 50 41 52 45 44 03 4C 22 FE C9 46 D0 0D A9
FF20: 01 85 28 D0 BF B1 FA C9 FF 4C F4 FE C9 52 D0 59
FF30: 20 D3 1E 20 8C FF 20 95 FF 20 5C 1E C0 03 D0 2D
FF40: 88 88 B1 E6 38 E5 E2 C8 B1 E6 E5 E3 90 1F 88 A5
FF50: E4 F1 E6 C8 A5 E5 F1 E6 90 13 18 88 B1 E6 65 EA
FF60: 91 E6 91 FA C8 B1 E6 65 EB 91 E6 91 FA A4 F6 20
FF70: 13 12 88 D0 FA 20 A3 FF B0 BF 20 F2 FA 0D 0A 52
FF80: 45 4C 4F 43 41 54 45 44 03 4C 22 FE A5 E8 A4 E9
FF90: 85 FA 84 FB 60 38 A5 E8 E5 E2 85 EA A5 E9 E5 E3
FFA0: 85 EB 60 18 A5 E6 65 F6 85 E6 A5 E7 69 00 85 E7
FFB0: B0 0A 38 A5 E4 E5 E6 A5 E5 E5 E7 60 18 90 FC 68
FFC0: 68 68 20 CF FB A5 E3 20 D8 FB A5 E2 20 D8 FB 20
FFD0: F2 FA 3C 3D 41 44 3D 3C 03 A5 E5 20 D8 FB A5 E4
FFE0: 20 D8 FB 20 F2 FA 20 54 4F 20 3E 3D 03 A5 E9 20
FFF0: D8 FB A5 E8 20 D8 FB 4C 22 FE 2F 1F 1D 1C 32 1F
```

Table 2. Hex dump of the cruncher.

The R (RELOCATE) key. All the absolute addresses *within* the data block SORSA . . . SOREA are adapted to the new situation brought about by moving or programming a data block. The new address is determined by the contents of DIF (see figure 1). At the end of the procedure, 'RELOCATED' is printed. The R key function is not needed while relocatable software is being stored (without any internal JMPs and subroutines) or if the contents of one EPROM are being loaded into another. In order to copy RAM data into EPROM, depress R, then M. But to store EPROM data into RAM, depress M followed by R.

The V (VERIFY) key. This compares the original data block and its relocated version, byte by byte. Whenever an error crops up, the offending location is printed along with its address and contents. The operation signs off with the 'DATA COMPARED' message.

The B (BACK) key introduces a return to PM whenever the computer is ready or the operator wishes to disassemble a relocated/programmed data block (to verify the R key routine).

The ST key (ST/NMI on the main keyboard) allows a return to take place from PM to EPRUTL, like a warm start entry. Then 'XXXX < = AD = < YYYY TO > = ZZZZ' appears, where XXXX stands for the FIRST SOURCE ADDRESS, YYYY stands for the LAST SOURCE ADDRESS and ZZZZ stands for the FIRST DESTINATION ADDRESS.

By the way, ST may also be operated during EPRUTL to print the three address parameters and their interim status during an operation. This is extremely useful, as sometimes the parameters need to be temporarily altered. At the same time, the operator is reminded of what was entered three 'screenfuls' before.

How to prevent programs from going 'off the rails'

1. The EPROM programmer must be connected to the bus board. The card is addressed in the normal manner during programming. This means that a 'FIRST DESTINATION ADDRESS' ($2000 or higher) must be entered for reasons described in Book 3. But this does not imply that any EPROM data located below $2000 in the memory map, such as the main board monitor and the TM and PM software, is excluded. Details are provided in point 3.
2. Using the S3 . . . S6 switches, a 4K address block must be selected that does not coincide with any existing data blocks. Otherwise double addressing occurs. If necessary, remove one or two memory cards from the bus board for the time being. Remember that the first two 4K blocks are also out of bounds (see point 1).
3. The FIRST DESTINATION ADDRESS entered just before the start of the program must be located within the selected 4K block (see point 2). This address does not necessarily have to be the ultimate first address (it may be modified later). Right now we intend to load data into the EPROM on the programmer, byte by byte, with the aid of the M key. But take heed! If any absolute addresses need to be altered, start by entering the *real* FIRST DESTINATION ADDRESS using the P key. (Then depress R and P again, followed by the first address of the EPROM programmer.) Finally, operate M.
4. S2 on the EPROM programmer is not switched 'on' until just before the actual programming sequence (with the M key). During programming LED D9 lights and remains lit for the entire process. (About 20 bytes are loaded per second, so it takes quite a while). S2 should be switched off as soon as D9 has gone out and 'DATA MOVED' appears on the screen!
5. 2716 and 2732 EPROMs have one thing in common: they do not enjoy being exposed to the full brunt of the 25 V programming voltage without having the comforting protection of the 5 V supply voltage. The circuit in figure 2 is added to the EPROM programmer hardware 'to cushion the blow'.
6. To find out whether a 2716 IC is truly empty, access a 4K block on the EPROM programmer; select a FIRST DESTINATION ADDRESS that either corresponds to the first address in the range or to one 2048 locations further on, and enter any 2K data block. Now depress the F key.
7. Whenever EPROM software needs to be duplicated, store the 'master' version on a RAM/EPROM card, (unless it is a system EPROM). Insert the (presumably) empty EPROM on the programmer board. Then follow the instructions given in points 3 and 4. After a short while the data 'transfusion' should be complete.
8. Loading EPROM software into RAM is no problem and may come in handy whenever system programs are to be stored on cassette or the contents of an EPROM are to be changed. First copy the data (using the M key) and then relocate it (with the R key), if necessary. The V key allows the operator to check which locations have been altered as a result of the R key routine.
9. When using the R key, watch out for look-up tables and 'strings'! Data such as '20 41 54' is ambiguous, for it may either be the ASCII code for '␣AT', or stand for JSR-$5441! If 54 constitutes an ADH within the data block being programmed ($2000 . . . $5FFF on the dynamic RAM card) the chances are, operating the R key will cause the 54 to be deleted. That is why it is a good idea to check the location of such tables beforehand, and make sure they remain intact after R is depressed (before M is operated). The disassembler is of great help in these matters.
10. A special program, as described in the January article on EPROM software, would be needed to store data in the 'step' mode using the original monitor routine. Fortunately, this is no longer necessary, thanks to the PM routine. Just enter the EPROM location to be programmed (the EPROM programmer version! see point 3), depress the space bar, enter the data and press the '.' key. Make sure the EPROM programmer is ready for programming, as indicated in point 4.

Although very few keys are needed to program EPROMs, operators will discover that they offer a surprisingly versatile repertoire.

2

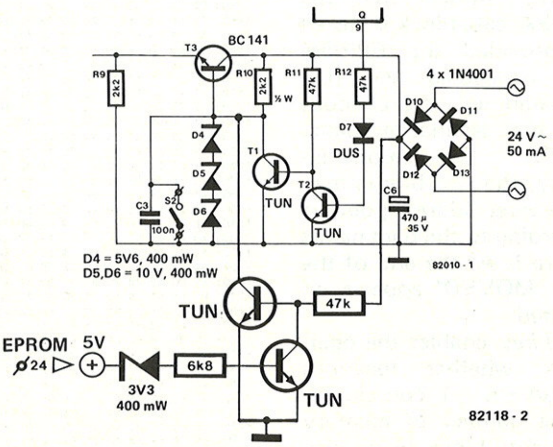


Figure 2. This circuit is added to the EPROM programmer to prevent the EPROM being loaded from becoming a fried chip if S2 is inadvertently switched on before the EPROM programmer power supply is connected up. A common mains switch does not provide a 100% guarantee!

We are informed that a suitably programmed 2716 will be available from Technomatic Ltd, London.

market

'Small business' printer

The latest family of bi-directional logic seeking dot matrix printers from Centronics Ltd — the 150 series — is now being stocked by Bytech Limited. These versatile 150 character per second machines are available for either 10-inch or 15-inch paper widths, and have snap-on tractors to handle roll, cut-sheet or fan-fold paper.

The series, which comes complete with a time-saving cassette ribbon system, features a 96 ASCII character set, plus an optional international character set. Printing may be carried out in 40, 80 or 132 column format, using a 100% duty cycle. A self testing facility and cover safety interlook complete the relatively sophisticated functions offered, and both types are available with either serial or parallel interfaces.

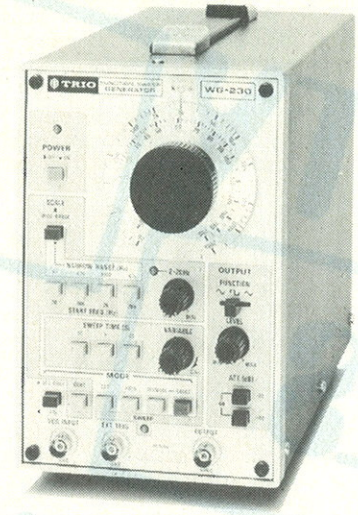
Bytech Limited,
Unit 57, Suttons Ind. Park,
London Road,
Earley,
Reading,
Berks.
Telephone: 0734-61031

(2348 M)

Combined function, sweep and pulse generator

House of Instruments announce the WG 230 from Trio, which combines the capabilities of a function, sweep and pulse generator in one high quality compact unit. The wide frequency bandwidth is covered by a log and linear divided, high resolution main dial from 20 Hz to 200 kHz, with an auxiliary control covering the range 2 Hz to 20 Hz.

Four main types of output are available: sine, square, triangle and TTL level pulse. Output impedance is 600 ohms with 7 V rms sine and 10 V pp for square and triangle controlled by 60 dB of switched and 20 dB of variable attenuation. Flatness is better than 0.2 dB making the WG 230 ideal in determining frequency characteristics. The TTL pulse output can be used to drive logic circuitry or act as a clock source substitute. FM modulation, another convenient feature when measuring frequency characteristics over a specific band, is available via an external signal. External DC can be used for VCO applications while a useful sweep ramp output is provided for use as a time access control for oscilloscopes or pen recorders.



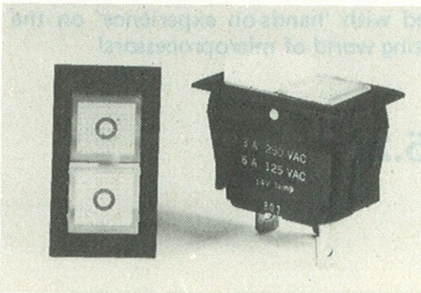
Up to five frequency decades can be covered in a single sweep with automatic sweep times being internally selected from 0.1 to 100 seconds both continuous and single to match the application. The single sweep mode can also be controlled manually from the front panel or sweep speeds determined by external signals. Automatic sweep speed compensating has been provided to maintain a constant sweep time period for any arbitrarily set width. The WG 230 is neat and compact, measuring 128 (W) x 190 (H) x 285 (D) mm and weighing approximately 4.2 kg.

House of Instruments,
Clifton Chambers, 62,
High Street,
Saffron Walden,
Essex CB10 1EE.
Telephone: 0799-24922

(2345 M)

Pushette switches

A new line of pushbutton switches is now available from N.S.F. Limited. Standard features of the Pushette switches include illuminated and non-illuminated buttons, interlocking buttons, solder lug, spade and screw terminal, maintained and momentary circuits, bezels and two methods of snap-in mounting. The new pushbutton switches are interchangeable with standard snap-in rocker switch models, thus using the same panel cut-outs and so can be substituted without re-tooling of the existing panel.



Illumination is provided by either neon or incandescent lamps through red, green and amber actuator buttons whilst the non-illuminated thermoplastic buttons are available in red, white and black. Both types can be hot stamped in red, white and black, with legends to customers' specifications.

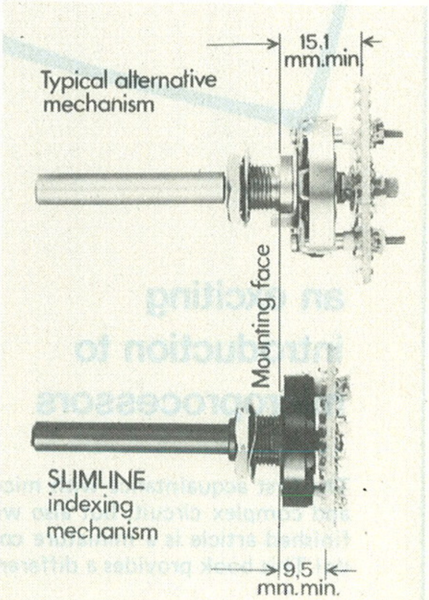
Pushette switches have a 125 V AC/28 V DC rating of up to 10 amps 250 V AC and models are available for low voltage DC applications.

N.S.F. Limited,
Keighly,
West Yorkshire BD21 5EF,
Telephone: 0535-61144

(2341 M)

Slimline wafer switch

Where behind panel dimensions are critical, especially in applications incorporating printed circuit rotary wafer switches, the new Slimline mechanism provides a smooth, efficient and positive indexing, all in a slender package. Being a 'ready finished' component, the all moulded construction gives protection against corrosion and requires no additional lubrication. The saving in length, compared with existing alternative models, is approximately 5 mm to the first stator. With 30 and 36 degree indexing available, the switching ranges from 1 pole, 2 to 12 ways up to 6 poles, 2 ways per wafer, and the 12 or 14 pin terminations of the PCA stator board are positioned conveniently along one edge for easy attachment to printed circuit boards.



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Keighley,
West Yorkshire BD21 5EF.
Telephone: 0535-61144

(2336 M)

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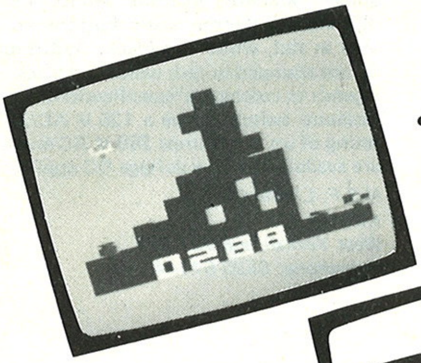
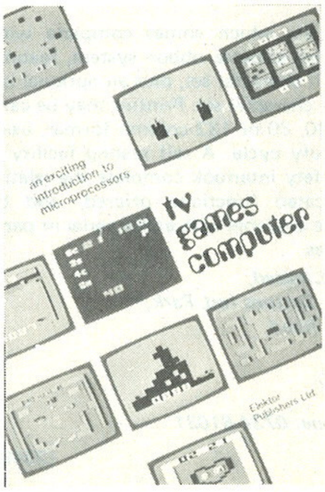


TV GAMES COMPUTER BOOK



an exciting introduction to microprocessors

The first acquaintance with microprocessors can be rather frightening. You are not only confronted with a large and complex circuit, but also with a new language: 'bytes', 'CPU', 'RAM', 'peripherals' and so on. Worse still, the finished article is a miniature computer and so you have to think up some sufficiently challenging things for it to do! This book provides a different — and, in many ways, easier — approach.

The TV games computer is dedicated to one specific task: putting an interesting picture on a TV screen, and modifying it as required in the course of a game. Right from the outset, therefore, we know what the system is intended to do. Having built the unit, 'programs' can be run in from a tape: adventure games, brain teasers, invasion from outer space, car racing, jackpot and so on. This, in itself, makes it interesting to build and use the TV games computer.

There is more, however. When the urge to develop your own games becomes irresistible, this will prove surprisingly easy! This book describes all the component parts of the system, in progressively greater detail. It also contains hints on how to write programs, with several 'general-purpose routines' that can be included in games as required. This information, combined with 'hands-on experience' on the actual unit, will provide a relatively painless introduction into the fascinating world of microprocessors!

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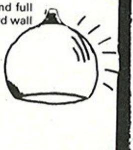

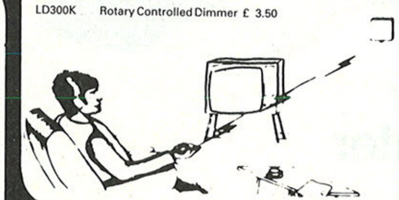

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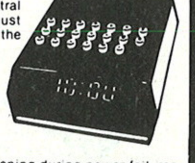

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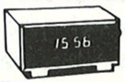

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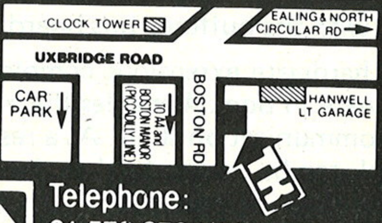
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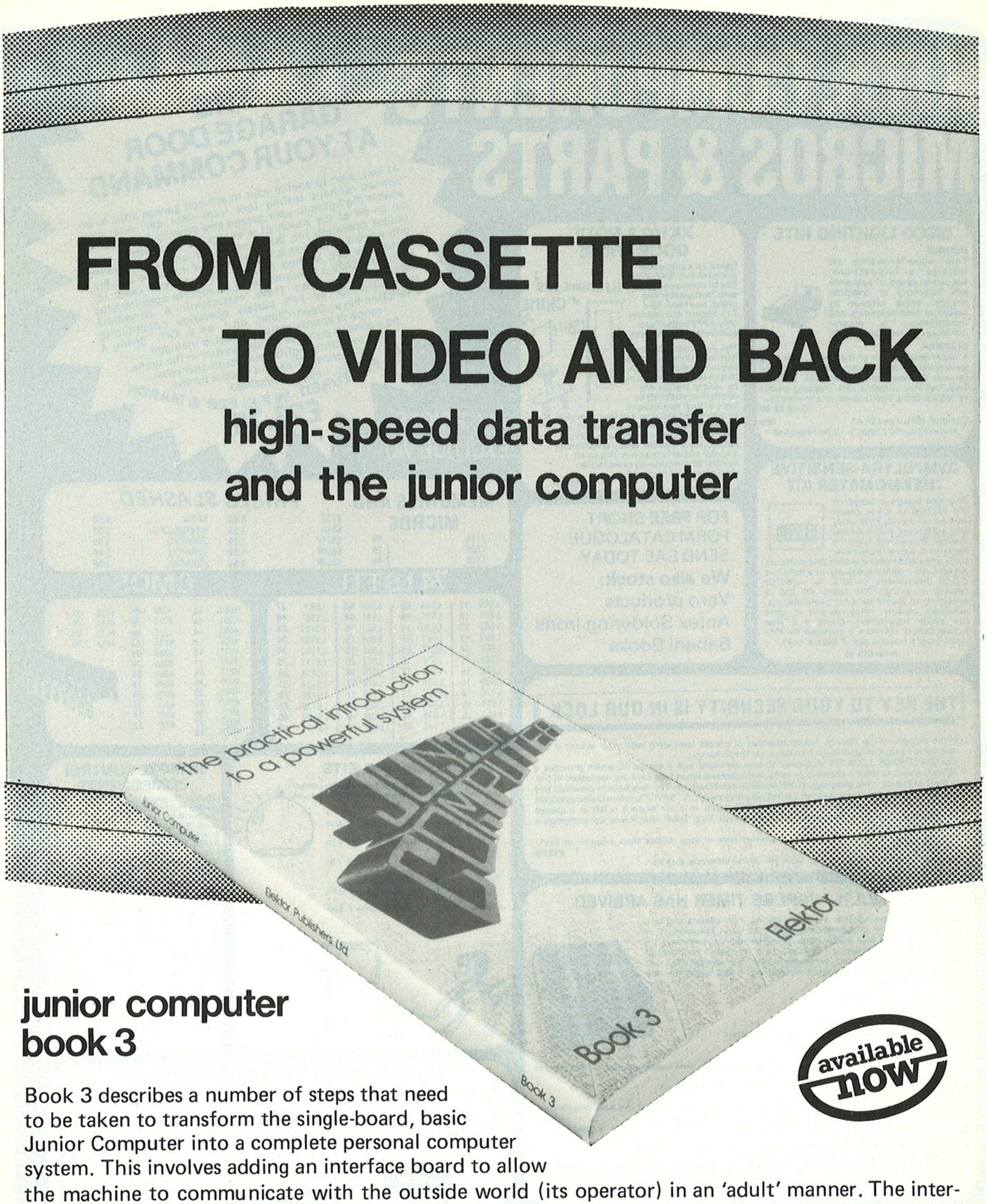

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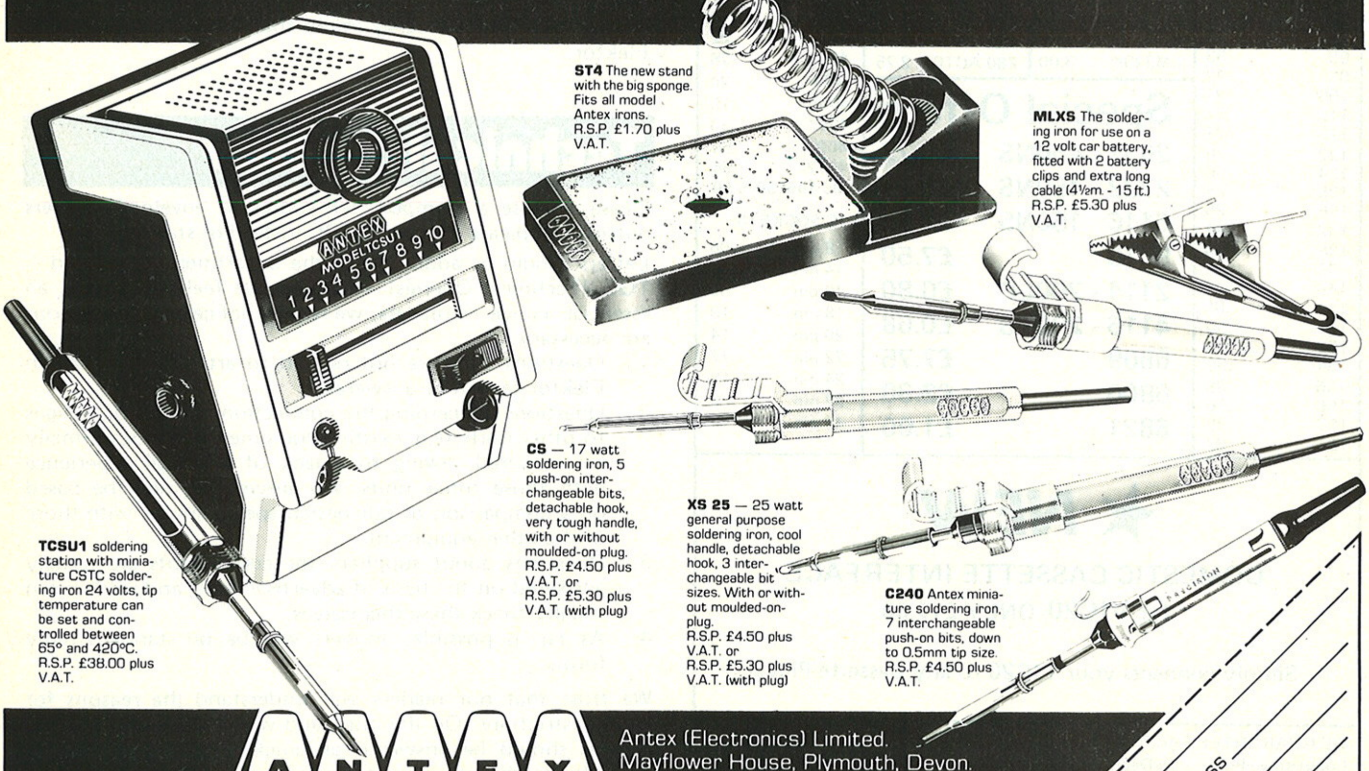

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148	.85
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153	.28
154	.80
155	.38
156	.36
157	.30
161	.37
162	.40
163	.38
164	.46
165	.90
173	.69
174	.46
175	.45
193	.45
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LM3916	2.00
BC237	.07
MC1413P	.70
MC1488P	.57
MC1489P	.60
MC14069	.35
MC14093	.30
MC3242	4.20

CRYSTALS	
1,000MHz	2.75
2,000MHz	2.65
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3,579MHz	1.00
3,932MHz	1.00
4,000MHz	1.40
4,194MHz	1.25
6,000MHz	1.00
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4013	.22
4024	.28
4066	.24
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4093	.30
4099	.50
4512	.55
MC 14515P	5.99

IC SOCKETS	
8 pin	.06
14 pin	.09
16 pin	.09
18 pin	.13
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22 pin	.17
24 pin	.18
28 pin	.25
40 pin	.25

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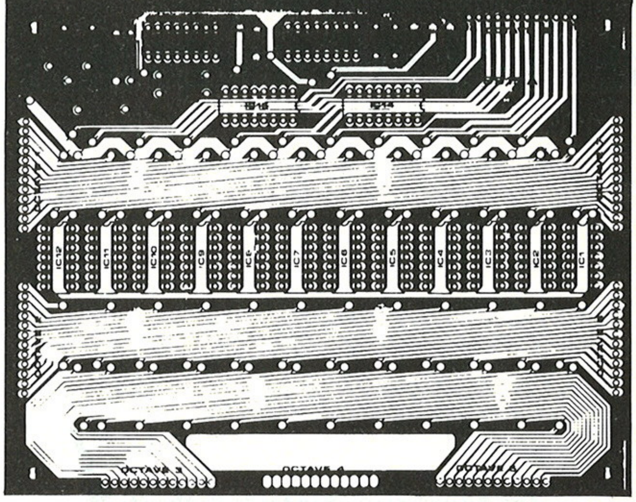
SERVICES TO READERS



EPS print service

Many Elektor circuits are accompanied by printed circuit designs. Some of these designs, but not all, are also available as ready-etched and pre-drilled boards, which can be ordered from any of our offices. A complete list of the available boards is published under the heading 'EPS print service' in every issue. Delivery time is approximately three weeks.

It should be noted however that only boards which have at some time been published in the EPS list are available; the fact that a design for a board is published in a particular article does not necessarily imply that it can be supplied by Elektor.

Technical queries

Please enclose a stamped, self-addressed envelope; readers outside UK please enclose an IRC instead of stamps.

Letters should be addressed to the department concerned — TQE (Technical Queries). Although we feel that this is an essential service to readers, we regret that certain restrictions are necessary:

1. Questions that are not related to articles published in Elektor cannot be answered.
2. Questions concerning the connection of Elektor designs to other units (e.g. existing equipment) cannot normally be answered, owing to a lack of practical experience with those other units. An answer can only be based on a comparison of our design specifications with those of the other equipment.
3. Questions about suppliers for components are usually answered on the basis of advertisements, and readers can usually check these themselves.
4. As far as possible, answers will be on standard reply forms.

We trust that our readers will understand the reasons for these restrictions. On the one hand we feel that all technical queries should be answered as quickly and completely as possible; on the other hand this must not lead to overloading of our technical staff as this could lead to blown fuses and reduced quality in future issues.

for your copies of Elektor —

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This cassette style binder will help to keep your copies of Elektor clean and in order, even though you refer to them time and time again. The chamfered corner of the cassette allows instant recognition of each month's issue without the need to thumb through pages of previous months' issues.

Because no wires or fastenings are used copies can be easily removed and replaced and each cassette will hold one year's volume of Elektor. Their smart appearance will look good on any laboratory shelf.

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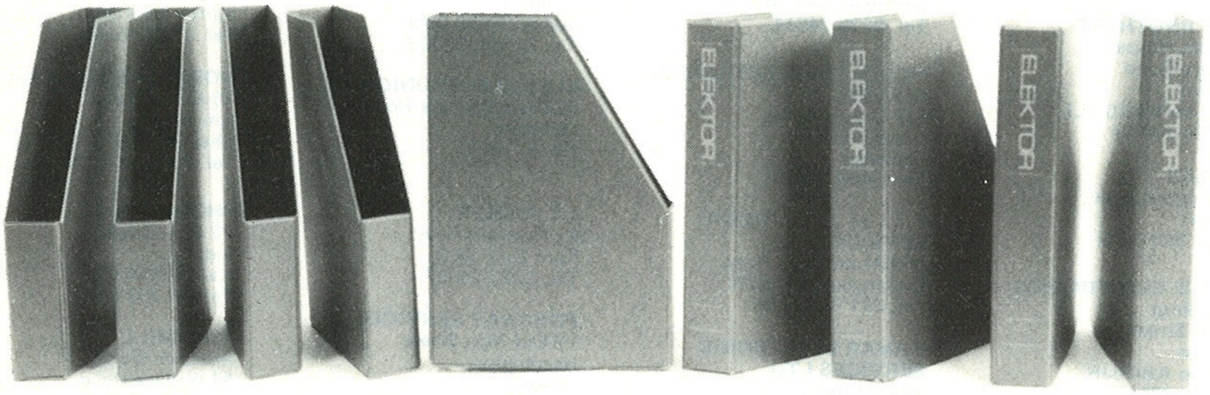

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We invite our readers to insert advertisements into our 'Classified Section'.

If you have something to sell, exchange, or buy, fill in this form and send it to us with your remittance.

The rate (prepaid) is 20p per word. Minimum charge is £2.40 (12 words). Please read Conditions of Acceptance on Classified ads page.

When completing the form use CAPITAL LETTERS, one word per box. Your advertisement must include your address or telephone number. Please also add your name and full address below.

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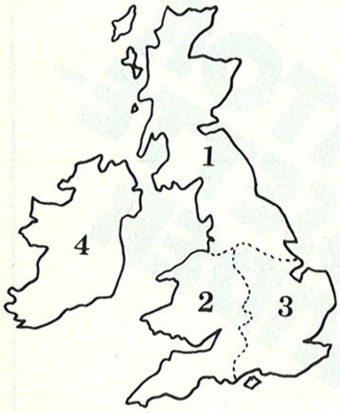

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Boundary Road
St. Helens
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Tel. 0744 27873

DOUGLAS
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Stockport
Cheshire SK1 3AQ

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Peterhead
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1364 Copenhagen K

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classified ads

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1. Advertisements are accepted subject to the conditions appearing on our current rate card and on the express understanding that the Advertiser warrants that the advertisement does not contravene any Act of Parliament nor is it an infringement of the British Code of Advertising Practice.

2. The Publishers reserve the right to refuse or withdraw any advertisement.

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4. The Advertiser's full name and address must accompany each advertisement submitted.

The prepaid rate for Classified Advertisements is 20 pence per word (minimum 12 words). Semi-display setting £5.50 per single column centimetre (minimum 2.5 cms.). All cheques, postal orders, etc. to be made payable to Elektor Publishers Ltd. Treasury notes should always be sent by registered post. Advertisements, together with remittance, should be sent to the Classified Advertisement Manager, Elektor Publishers Ltd., 10 Longport, Canterbury, Kent CT1 1PE.

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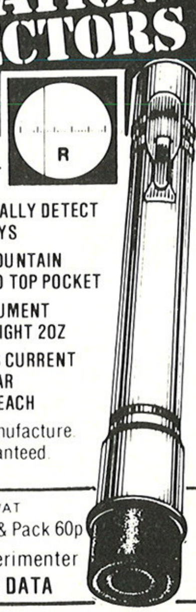

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classified ads

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AND CO-STARRING : Cappy the capable capacitor

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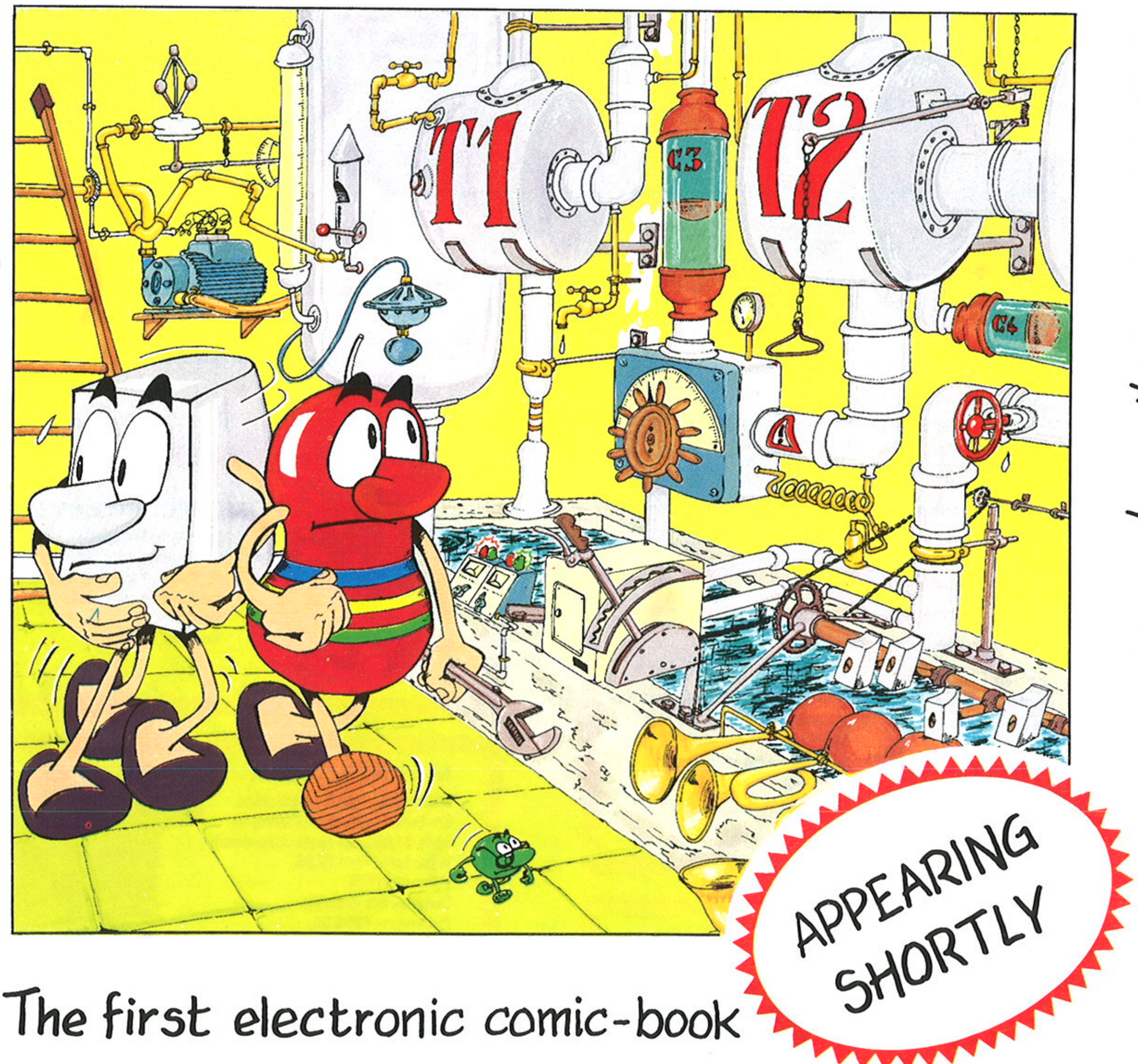

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Photo by W.A. Sharman.

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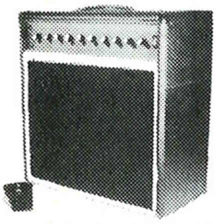

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E582

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